

BULLETIN 158

**THE MARINE ALGAE OF THE LABRADOR
PENINSULA AND NORTHWEST NEWFOUNDLAND
(ECOLOGY AND DISTRIBUTION)**

BY

ROBERT T. WILCE

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Robert T. Wilce

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CONTENTS

	PAGE
Introduction.....	1
Acknowledgments.....	2
Literature review.....	3
Comparison of arctic-subarctic marine floras with those of the Maritime Provinces and New England.....	8
Aspects of temperate eastern vegetation.....	8
Aspects of Canadian eastern arctic-subarctic vegetation.....	9
The physical character of the major regions.....	11
Northeast coastal Quebec.....	11
Coastal Labrador.....	11
Northwest and central west coastal Newfoundland.....	13
List of stations visited.....	13
General ecological considerations.....	19
Mud flats and associated habitats.....	23
Ecological factors in the littoral.....	23
Vegetation of mud flats.....	24
Vegetation of other littoral habitats associated with mud flats.....	24
Ecological factors in the sublittoral.....	25
Vegetation of the sublittoral.....	26
Periodicity.....	27
Protected shallows.....	28
Ecological factors in protected shallows.....	29
Vegetation.....	30
Periodicity.....	34
Moderately exposed coasts.....	35
Ecological factors along moderately exposed coasts.....	35
Vegetation.....	37
Periodicity.....	46
Fully exposed coasts.....	48
Ecological factors along fully exposed coasts.....	48
Vegetation.....	49
Periodicity.....	53
Tide pools.....	53
Ecological factors in tide pools.....	54
Vegetation.....	55
Periodicity.....	59

	PAGE
Species tabulation.....	63
Summary.....	74
Literature cited.....	76

Illustrations

	PAGE
Plate I A. Map of Newfoundland-Labrador.....	83
B. Map of Ungava Bay.....	83
II A. Map of Forbes Sound.....	85
B. Map of northwestern Killinek Island.....	85
III A. Pack-ice crowding the shore.....	87
B. Ice-scoured rocks of the littoral zone.....	87
IV A. Remains of ice-foot at Port Burwell.....	89
B. Ice-floes stranded on skerries.....	89
V A. Sheltered head of Nachvak Fjord.....	91
B. Intertidal mud flats, Fort Chimo.....	91
VI A. Fully exposed coast.....	93
B. Low littoral tide pool.....	93
VII A. Intertidal cobbles of an exposed shore, July.....	95
B. Intertidal cobbles of an exposed shore, August.....	95
VIII A. <i>Laminaria solidungula</i> , habit.....	97
B. <i>Laminaria solidungula</i> , holdfast.....	97
IX A. <i>Ralfsia fungiformis</i> , habit.....	99
B. <i>Dilsea integra</i> , habit.....	99
X A. Dredge haul on the deck of the <i>Blue Dolphin</i>	101
B. <i>Kallymenia schmitzii</i> , habit.....	101
XI A. <i>Rhodophyllis dichotoma</i> , habit.....	103
B. <i>Rhodophyllis dichotoma</i> f. <i>setacea</i> , habit.....	103
Figure 1.....	53

THE MARINE ALGAE OF THE LABRADOR PENINSULA AND NORTHWEST NEWFOUNDLAND

(ECOLOGY AND DISTRIBUTION)

INTRODUCTION

Only during the last 20 years have biologists had adequate means of transportation and other facilities necessary to carry out lengthy and detailed investigations in remote and inaccessible regions of the north. For this reason, the distribution and ecology of marine plants in the Eastern Canadian Arctic has remained until recently a little known phase of marine biology, in spite of increasing financial encouragement for studies of this nature. A few aspects of arctic and subarctic marine biology, however, are beginning to be well understood. For example, H. Madsen (1936), E. Bertelsen (1937), C. Vibe (1939), D. Ellis (1955), and others have contributed much to our knowledge of the attached marine fauna of the North. M. J. Dunbar, in a series of papers (1951, 1952, 1953), discussed certain aspects of marine ecology in relation to potential biological resources of the North and made clear the need for further biological studies in these environments. These investigators, and most others who have studied the biology of northern waters, have had as their primary interest certain aspects of zoology, and even in the papers concerning arctic marine ecology, the attached algae are slighted or neglected completely.

The most substantial contributions to arctic marine botany (Kjellman, 1883; Harvey, 1858; Taylor, 1937) are all based on deplorably incomplete distribution records and include little of the ecological relationships between plants and plant communities in the North. The Canadian Northeast Arctic and Subarctic are, therefore, particularly attractive and satisfying for field studies in this phase of marine biology.

The primary aims of this survey were to record the constituent species of the attached marine algal flora of the Labrador-Ungava region and to study their relationships to each other and to their environment. Field investigations extended from June to September, 1954, and from June through October, 1955. Laboratory studies were made during the winter of 1954-55 and the spring and summer of 1956. Collections were made at 38 stations along approximately 1,500 miles of coastline, including the central northwest coast of Newfoundland to the north shore of the Strait of Belle Isle, along the entire coast of the Labrador peninsula, and at one station in the vicinity of Frobisher Bay, Baffin Island. Many of these stations could only be visited briefly, while others, particularly those along the Strait of Belle Isle and in the vicinities of Hebron, Port Burwell, and the mouth of the Koksoak River, were studied for longer periods.

In carrying out this survey, transportation proved to be the most critical factor; for once I left the small native communities that are scattered throughout the coastal regions of the Labrador peninsula, a means

of travel was difficult, if not impossible, to obtain. The frequent unavailability of coastal transportation was a primary handicap, restricting the number and extent of the stations and, of even more importance, the amount of deep-water dredging.

In June, 1954, I travelled by commercial aircraft to Stephenville, Newfoundland, thence by train and coastal boat to the village of Red Bay, Labrador, where I joined the 1954 *Blue Dolphin* Expedition, which was bound for Hebron, Labrador. From Red Bay the *Blue Dolphin* sailed northward along the coast of Labrador, stopping in various coves because of weather and ice conditions, at which times I was able to observe the spring flora and to make collections. On July 6 we arrived at Hebron Harbour, and for the remainder of July and the first half of August I studied the marine plants of Hebron Fjord and the coastal regions near the mouth of the fjord. On August 15, I fortunately had the opportunity to join the R.C.M.P. medical patrol vessel *MacBrien* and to travel with its crew around Cape Chidley into Ungava Bay to Fort Chimo. Numerous collecting stops were made on the way, enabling me, in one summer, to survey marine plants at points along the entire coast of the Labrador peninsula. This brief introduction to the vegetation of the more northerly regions of the coast and Ungava Bay broadened the scope of my studies, and most assuredly provided me with a more substantial basis for an understanding of the vegetation found between Newfoundland and the northernmost regions of this area.

For the second season of field work, it was my intent to be at the northernmost station, established the previous year at Port Burwell, as soon after the spring break-up as possible. The trip north was made with the aid of the United States Military Air Transport Service and the Royal Canadian Air Force. With the help of six Eskimos I was able to travel by paterhead, a small open boat used extensively by the natives in place of the kayak, from Fort Chimo along the east coast of Ungava Bay, arriving two weeks later, on the 12th of July, at Port Burwell after much delay from floating ice and bitter weather. I remained on Killinek Island throughout August and arrived back at Fort Chimo with Constable R. Green of the R.C.M.P. on his return from summer patrol. Further services from the Royal Canadian Air Force enabled me to reach Goose Bay, Labrador, where the United States Air Force provided me with transportation to Saglek, on the east coast of the Labrador peninsula, near the area I wished to study during the autumn months. From here I travelled with a local group of Eskimos to the village of Hebron. The trip from Hebron to Goose Bay, by way of Saglek, was again managed with the aid of natives and the U.S.A.F. I arrived at a United States port of entry November 5, 1955, by United States military aircraft from Goose Bay.

ACKNOWLEDGMENTS

During the last three years I have received valuable assistance from many different individuals and organizations; I gratefully acknowledge this help. Professor W. Randolph Taylor has assisted me in many ways, which most certainly have enabled me to approach the problems of research

with more insight. I am in debt to Professor Taylor for the use of his personal herbarium and library and, at that time, his unpublished manuscript of the revised "Marine Algae of the Northeastern Coast of North America." His painstaking criticism of the first drafts of this paper has aided me enormously.

The extensive field work would have been impossible without financial assistance. These studies were aided by a contract between the Office of Naval Research, Department of the Navy, and the Arctic Institute of North America. Additional funds were provided by the Department of Botany of the University of Michigan.

I owe a great deal to those who have contributed much to the success of my work in the North, namely: David C. Nutt, Captain of the *Blue Dolphin*, and his crew for their kindness and co-operation and especially their help in the troublesome task of dredging; Per Scholander, for his support and willing assistance in field studies; Captain A. H. Cassivi, formerly of the Royal Canadian Mounted Police patrol vessel *MacBrien*, for taking me from Hebron to Fort Chimo with many interesting and important stops along the way; Constable Richard Green and Constable Richard Hopely, without whose generous assistance and provisioning the trip north in Ungava Bay could not have been attempted; the Moravian missionaries and the employees of the Division of Northern Labrador Affairs at Hebron for the many comforts provided me during my stay; and a score or more Eskimos for their help with some of the problems of transportation and living in the North.

I gratefully acknowledge the help of my wife Joan, in appreciation of her understanding and assistance during the preparation of this manuscript.

All the laboratory studies and the writing of the manuscript were done at the University of Michigan, and the MS. was submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

Grateful acknowledgment is made to the National Museum of Canada for making possible the publication of this study. A set of specimens forming the basis for this and a subsequent taxonomic report has been deposited in the Herbarium of the National Museum.

LITERATURE REVIEW

Botanical studies of the Arctic Archipelago north of the American continent are numerous and wide-ranging. There remain few small areas that have not been investigated, but most of our province¹ of the Arctic is represented to some extent by collections of varying numbers of land plants. The attached marine algae from these regions have been badly neglected, and what information we have concerning them is based on few, generally fragmentary collections and even fewer field observations. The reports consist mainly of short lists of plants with data, if any, limited to the latitude and longitude and perhaps the depth from which the plants were collected.

¹ The Canadian Northeast Arctic.

That our knowledge of arctic marine botany, notwithstanding the many expeditions to the North, has remained small is due both to the early collectors' lack of general interest in plants, especially in marine plants, and to their lack of botanical training. For the most part, the collectors were ships' officers or surgeons. Rarely has an experienced botanist, particularly a marine botanist, been included on such voyages of exploration.

Botanical records from the Canadian Northeast begin with the 1818 voyage of John Ross; the few flowering plants returned to England from this expedition were determined by Robert Brown (1819). The first records we have of marine plants from the area are those of J. Richardson (1823) included in a botanical appendix to the narrative of Sir John Franklin's first voyage. Richardson includes five algae, two of which are marine. The second record is from Captain G. F. Lyon's (1825) narrative of a voyage to reach Repulse Bay, in which he refers to a mass of "tangle-weed" somewhere off the west coast of Southampton Island. Of these plants Lyon writes, "The stalk of one piece which we measured, was eighteen feet in length, and the leaf, although a portion had been torn from its point, twelve feet six inches, making a total of thirty feet six inches." J. F. C. Montagne (1849) refers to two marine plants collected by F. V. Lamare-Picquot from "... the coast of Labrador," but unfortunately there are no precise data respecting them.

As one of the consequences of the loss of the Franklin Expedition, numerous searching parties were sent out from England during the mid 19th century. One of these, under the command of Captain Wm. Penny (1850-51), visited the west side of Baffin Bay and Barrow Strait. While there, Dr. P. C. Sutherland, the surgeon-naturalist of the party, was able to make a small but significant collection of marine plants. These were later determined by G. Dickie (1852) and constitute the first meaningful collections we have from this region. In many instances the validity of the data concerning the depths from which the plants were collected is rather doubtful. The following year Dickie (1853) published Sutherland's collections from this area made during the voyage of the English brig *Isabel* (1852) under the command of Captain E. A. Inglefield. Shortly after the middle of the 19th century the number of algae listed for the Canadian Eastern Arctic was less than 60 species (Dickie, 1852, 1853).

W. H. Harvey (1858), on the basis of various collections, listed 42 species of arctic algae. Of these, 11 were collected from the west side of Baffin Bay and had been previously reported; others listed were of general arctic distribution or from the eastern side of Baffin Bay.

In 1857 Lady Franklin privately sponsored a search expedition under the command of Captain M'Clintock in the steam yacht *Fox*. Dr. David Walker, the ship's surgeon, made valuable but small collections at Port Kennedy on the south coast of North Somerset Island, on which Dickie (1861) later published.

During the summer of 1861, Dr. I. I. Hayes of the U.S. brig *Advance* collected a small number of plants from the western side of Smith's Sound between lat. 78° and 82° N. These were reported by S. Ashmead (1864). A far more important contribution was the collection made by J. E. Taylor and subsequently studied and reported by Dickie (1867). Taylor, a surgeon on various whaling ships, visited the coast of

Baffin Island in the vicinity of Cumberland Sound during the summers of 1863-65, returning with extensive collections of marine and terrestrial plants. Dickie determined the algae and included a general description of the area from which they came. Moreover, notes concerning various aspects of the ecology, the abundance, and even the reproductive condition of the plants at the time of collection are included for the first time. Equally noteworthy in Dickie's paper is the summary of previous work, in which he lists the marine algae that have been found beyond lat. 60° N., and includes comments on arctic algal vegetation in general. In another shorter paper Dickie (1871) lists from the northeast shore of Lancaster Sound, in a deep inlet called 'Bethune Bay' (lat. $74^{\circ} 44' 24''$ N., long. 76° W.), nine marine algae of which he writes, "... all, with two exceptions are widely diffused, the only truly northern species being *Sphacelaria arctica* and *Polysiphonia arctica*."

In Brown's list of cryptogams from Baffin Bay, one marine algae is included (T. R. Jones, 1875). Both M. P. Merrifield (1875) and W. H. Dall (1875) give general accounts of the arctic marine vegetation based on the more detailed reports by Dickie and others. In 1875-76 Captain G. S. Nares succeeded in over-wintering one of his vessels on the north coast and the other on the east coast of Ellesmere Island. At both points various botanical collections were made. Dickie (1880) determined the algae and states, "... few species of the higher orders of algae were collected beyond 70° N. Lat.; the following are all that have come under my notice among the collections made by Captain Feilden, Mr. Moss and Mr. Hart." He lists 10 species, the exact localities, and in some cases the depths from which the plants were collected. These remain today as some of the northernmost algal records for the Eastern American Arctic.

W. G. Farlow (1879) lists 27 species of algae secured by the Howgate Polar Expedition to the Canadian Northeast Arctic. No mention is made of where the plants were collected, but they should be included in this discussion. Both Farlow (1881) and F. R. Kjellman (1883) record specimens from Labrador and northward in our province. These authors place the probable southern limits of the marine arctic environment as far south as the latitude of Nova Scotia and perhaps even to Cape Cod. However, many of their so-called arctic records are regarded today as actually sub-arctic or even cold-boreal.

Before the present investigation, the only noteworthy collection from Ungava Bay was made by L. M. Turner, employed as an observer for the U.S. Corps of Signals during the International Polar Year Expedition of 1882-84. Farlow (1886) reports 31 species from Turner's collection and 8 additional species from other districts of the arctic.

F. Børgeson and H. Jónsson (1905), using data of previous investigators, discussed the distribution of marine algae in the arctic and the northernmost part of the Atlantic. Referring to an extreme southward extension of arctic water in our region, they say, "It is quite impossible for us to set the limit on the American coast, but we suppose that a large border area is to be found which possibly extends southward to Cape Cod." This

transitional zone between arctic and warmer waters undoubtedly exists but does not extend south to Cape Cod or even to the latitude of Nova Scotia. It is therefore doubtful that many of the species they list from these southern regions can be considered arctic.

In his remarks on the relationships between the floras of the North Atlantic, the Polar Sea, and the northern Pacific, H. G. Simmons (1905) goes to the opposite extreme, stating, "... the parts of the American coast from Hudson Strait down to Newfoundland may be called arctic, but still it seems more natural to let them pass as temperate." It is little wonder that he does so in view of the fact that he relied heavily upon data from the studies of Farlow (1879) and F. S. Collins (1900), both primarily concerned with the marine flora of the New England states.

Two small collections from Hudson Bay, determined by W. A. Setchell and F. S. Collins (1908), are the first records for this area, but unfortunately, the data accompanying these plants are limited to "Drift, on Depot Island in Lat. $63^{\circ}55'$ N., and western shores of James Bay between the latitudes of 51° and 55° N." The next collection from Hudson Bay, accompanied by detailed station descriptions by F. Johansen, was reported by M. A. Howe (1927), bringing the total to 61 species for this area.

In 1906, B. Hantzsch of Dresden, Germany, spent considerable time on the island of Killinek and in nearby regions of the mainland, collecting various objects of biological interest, particularly birds. Although his well-documented collections of other forms of plant life are extensive, his only remark concerning the marine flora is "... the rocks were covered with an abundance of different seaweeds of soft olive-green to dark brown up as far as the high water mark" (Hantzsch, 1909).

Most of the marine algae returned by the second Norwegian Arctic Expedition (1898-1902) was collected by the expedition's botanist, Simmons. A few were obtained incidental to bottom fauna dredgings made by the zoologist, E. Ray. These were from various points on Ellesmere and North Devon Island and remain the most noteworthy collections we have from the northern parts of our province. L. K. Rosenvinge (1926) reported 61 species from these collections, 29 being new for the region, which, with the 65 previously known ones, bring the total specific entities to 94. In addition to interpreting Simmons' field notes on algal ecology for the general area, Rosenvinge includes complete descriptions and auto-ecological notes for many of the species.

Collins (1927) recorded two species of red algae from Wakeham Bay, Quebec, collected by F. Johansen during the 1904 *Neptune* Expedition. During the *Godthaab* Expedition of 1928, numerous stations were established on the east side of Baffin Bay. Only two, however, were in our province, namely, Craig Harbour, lat. $72^{\circ}24'$ N., and Exeter Sound, lat. $69^{\circ}19'$ N., long. $62^{\circ}18'$ W. Referring to the 16 algal species returned with the expedition, S. Lund (1933) comments, "In all cases the species are represented by one to a few plants or, for many, only drifting fragments."

H. P. Bell and C. MacFarlane (1933) recorded a third collection from Hudson Bay, resulting from the 1927-30 expedition of the Biological Board of Canada. N. Polunin (1934, 1935, 1948) makes frequent reference to the marine flora of the Canadian Eastern Arctic, although his treatment is at

times casual, apparently based upon few and hurried observations, owing chiefly to the limited time for biological collecting while travelling with the Eastern Arctic Patrol. R. M. Wheldon (1947) reports on 36 species of marine algae collected by Polunin during short visits to various stations in the Canadian Northeast; many of these records, however, are doubtful extensions of more southern species into these areas.

G. Gardner (1937) recorded three algae from the southern coast of Labrador collected in brackish water. Other collections from Labrador, Hudson Bay, and the northern side of Hudson Strait were made in 1934 by D. Leechman of the National Museum of Canada and were described by Bell and MacFarlane (1938). These, together with the other records previously given, now enable us to characterize the floras of these regions, especially Hudson Bay.

The most recent description of the marine floras of the Canadian Arctic is by Taylor (1954) in his review of the literature of the entire arctic marine flora. He here presented the viewpoints of various earlier writers and clearly stated the need for further marine studies in this part of the north.

Lund (1951), who is primarily concerned with the algae of central northeast Greenland, compares the northernmost algal records of northeastern North America as well as those of east and west Greenland and Spitsbergen with the records from J rgen Br nlunds Fjord in northeastern Greenland.

W. R. Taylor (1957), in his general flora of the marine algae of the northeastern coast of North America, included all records believed to be authentic for the northeastern Canadian Arctic and Subarctic. Taylor briefly discussed the ecology of broad areas and cited certain species he believes to be characteristic of these areas.

It is not within the scope of this investigation to discuss all the papers dealing with arctic marine algae; however, the more significant investigations concerning the marine vegetation of arctic provinces other than our own should be mentioned. In the Old World Arctic, as well as in the American Arctic, there have been relatively few individuals going into the North specifically to study marine plants. Hence the areas that have had more than a cursory survey are also few, notable exceptions being the east and west coasts of Greenland, the islands of Spitsbergen, Iceland, Jan Mayen, and Novaya Zemlya, and small portions of the eastern and western Soviet Arctic. Our knowledge of arctic algae from other than the North American sector is based primarily upon the studies of the following: Kjellman (1875, 1877a, 1877b, 1879, 1883a, 1883b, 1889, 1903, 1906), E. S. Sinova (1929, 1933, 1954a, 1954b, 1956), J nsson (1901, 1903, 1904, 1912), Lund (1933, 1951, 1954), and A. D. Sinova (1954a, 1954b). Although J. G. Agardh (1862, 1868, 1871, 1872) and B rgeson (1894, 1896) might well be included, the chief contributions have been made by the former investigators.

COMPARISON OF ARCTIC-SUBARCTIC MARINE FLORAS WITH THOSE OF THE MARITIME PROVINCES AND NEW ENGLAND

To bring more clearly into view the nature of the vegetation of the Labrador peninsula, I have compared it with the better known marine vegetation of the Maritime Provinces of Canada and that of New England. This comparison is based upon my own observations as well as upon the studies of others who have investigated the flora of various regions south of Newfoundland [De la Pylaie (1824, 1829), Farlow (1881), Davis (1913), Bell (1927), Johnson and Skutch (1928), Bell and MacFarlane (1933a, 1933b), MacFarlane (1933), Taylor (1937), and T. A. and A. Stephenson (1954)]. The appearance of the Labrador peninsula coast and its marine vegetation is strikingly different in every aspect from that of any other region of northeastern North America.

Aspects of Temperate Eastern Vegetation

Littoral. In the littoral zone one sees, where optimal environmental conditions are present, the most dense populations of marine algae in temperate eastern North America. Here one can study a much larger number of species and individuals than in the corresponding zone farther north. Characteristic are well-developed plant communities including such species as—

<i>Codiolum gregarium</i>	<i>Enteromorpha linza</i>
<i>Enteromorpha prolifera</i>	<i>Petalonia fascia</i>
<i>Ulva lactuca</i>	<i>Scytosiphon lomentaria</i>
<i>Cladophora rupestris</i>	<i>Bangia fuscopurpurea</i>
<i>Spongomorpha lanosa</i>	<i>Chondrus crispus</i>
<i>Ralfsia verrucosa</i>	<i>Gigartina stellata</i>
<i>Sphacelaria radicans</i>	<i>Ceramium rubrum</i>
<i>Chordaria flagelliformis</i>	<i>Rhodomela confervoides</i>

In the intertidal zone these species and others form sharply contrasting belts, which are absent or not well established in the littoral zone of the North.

Sublittoral. The sublittoral zone to considerable depths may at times be as heavily populated as the littoral zone. Many of the sublittoral plants, especially in the Maritime Provinces, are often large and frequently occur in prodigious numbers, forming dense and luxuriant populations of such species as—

<i>Halopteris scoparia</i>	<i>Dumontia incrassata</i>
<i>Desmarestia viridis</i>	<i>Corallina officinalis</i>
<i>Punctaria plantaginea</i>	<i>Melobesia membranacea</i>
<i>Dictyosiphon foeniculaceus</i>	<i>Agardhiella tenera</i>
<i>Laminaria agardhii</i>	<i>Callithamnion baileyi</i>
<i>Laminaria digitata</i>	<i>Grinnellia americana</i>
<i>Alaria esculenta</i>	<i>Polysiphonia nigrescens</i>
<i>Alaria pylaii</i>	

Aspects of Canadian Eastern Arctic-Subarctic Vegetation

The term 'arctic,' according to Dunbar (1953), when applied to marine environments, should only be used to describe water masses of "unmixed polar origin." Subarctic marine areas include mixed water of polar and non-polar origins. For Dunbar the subarctic extends from "... the Scotian Shelf and Hudson Strait to the Barents and Kara seas, and including almost the whole coast of west Greenland, much of the Norwegian Sea, and the waters of the west coast of Spitsbergen." He interprets the marine habitats of the arctic and the subarctic as being environmentally distinct, each with a characteristic fauna. Both Madsen (1936), working along the east coast of Greenland, and Ellis (1955), in his investigation of the fauna of the intertidal areas of southeastern and central Baffin Island, support this viewpoint on the basis of a sharply defined latitudinal distribution of certain of the intertidal invertebrates.

From the standpoint of phycology, I believe Dunbar is probably correct in considering the coast in the vicinity of Killinek Island and the upper regions of the Labrador peninsula subarctic. I have not at this time had the opportunity to study plants in areas that Dunbar considers arctic. However, I have found a higher percentage of species, which others (Kjellman, 1883; Børgesen and Jónsson, 1905; Jónsson, 1912; and Taylor, 1937) consider to be constituents of an arctic marine vegetation, in the northern part of my range than at the latitude of Hebron and farther south. Also, these arctic 'indicator' plants are found higher on the shore at Killinek Island than at Hebron, where, in fact, the typically 'arctic' species are found mostly in the deeper offshore waters. This difference may be due to the colder water temperatures or to the higher tides in the more northerly of the two regions or possibly to a combination of both factors. Equally important is a group of species, which may be considered 'boreal-subarctic,' occurring throughout the length of the coast, although becoming progressively less frequent toward the north. These plants actually are in greater number than the so-called 'arctic' species throughout the northern end of the range. There is most certainly an overlap of arctic and boreal floras, but as a result of the cold southward moving waters of the Labrador Current, truly arctic components of the northern flora may be found in regions far to the south of what is normally considered an arctic marine environment. Until I have had the opportunity to study and collect in marine environments of the higher latitudes, no additional comments as to the nature of the algal flora of northern Labrador will be made.

Littoral. The paucity of the littoral vegetation in northern regions is in striking contrast to the density and frequent luxuriance of the littoral vegetation to the south. Areas in this zone with little or no protection may support a few individuals, but barren rock is more common. Only the most protected intertidal areas, e.g., rock niches and the lee of large rocks, are clothed with vegetation, which throughout most of the year is scanty, consisting of such perennials as *Rhodochorton purpureum*, *Hildenbrandia prototypus*, *Ralfsia fungiformis*, and various fuci. During the ice-free summer months, however, rich populations of annuals, most frequently *Pylaiella littoralis*, *Prasiola crispa*, and *Spongomorpha arcta*, also appear.

Sublittoral. The bulk of the macroscopic marine algal life is unevenly distributed throughout the lower sublittoral zone, where many species manifest considerable vertical distribution and where frequently one finds immense quantities of plants. The major associations here include primarily the Fucaceae, Laminariaceae, and Corallinaceae, although the latter contributes comparatively little to the total bulk of plant life. The presence of an ice-mass, 2 to 3, and in some places up to 4, metres thick, covering the entire coastal water for much of the year strongly affects the character of the sublittoral flora. The reduction of light intensity by the ice-sheet produces very unfavourable conditions, particularly for plants in deep water. The sustained movement of the ice-mass throughout much of the year, in addition to the great influx of fresh water from melting snow and ice, leaves the upper sublittoral as poor as the littoral zone in the number of larger attached algal forms.

The chief difference between the sublittoral flora of the North and that of temperate eastern North America is the greater number of secondary species, consisting mostly of smaller plants, found farther south. There are many instances in the north where the algal undergrowth is reduced or wanting. This seems to be related to an increase in exposure and a parallel increase in shelf rock as substratum. When algal undergrowth is present, it is, in most instances, so completely dwarfed by the size and bulk of the members of the dominant Laminariaceae that it lends little to the general aspect of the flora. In some relatively quiet coastal areas this relationship is greatly modified; occasionally I have seen such areas where the algal undergrowth becomes conspicuous, consisting of extensive populations of larger plants such as *Desmarestia aculeata*, *Dictyosiphon foeniculaceus*, and *Rhodymenia palmata*. This must surely be the case in the deeper offshore water of southeastern Ungava Bay where great quantities of leafy rhodophycean species, e.g., *Kallymenia schmitzii*, *Phyllophora interrupta*, *Phycodrys rubens*, and *Odonthalia dentata*, are commonly found in the drift.

The flora of the North, lacking diversity of species, also lacks variety of colour; the subtle blending of red, green, and brown so common in the littoral and sublittoral zones of our temperate eastern coast is almost completely missing. This seems to be the character of the vegetation of northern waters in general, as Kjellman (1883) states, "The vegetation of the Arctic Sea lacks variety not only in form, but also in colour. The general tone is gloomy; the dark-brown colour of the Laminariaceae is the prevailing one."

In summary, one may say that distinct differences in nature and composition exist between the two floras. These differences seem to be directly related to the physical characteristics of the marine environment of each broad area. The marine flora of the Canadian Eastern Arctic and Subarctic is therefore marked by a reduced number of species, relative restriction to a sublittoral vegetation, and dominance of Fucaceae, Laminariaceae, Corallinaceae, with the general aspect determined by the form and drab colour of its major constituents, the Laminariaceae.

THE PHYSICAL CHARACTER OF MAJOR REGIONS

For clarity of presentation I have divided the entire area over which this investigation ranged into three general readily defined regions, as follows: (1) the coast of northeast Quebec (Plate I B), (2) the coast of Labrador (Plate I A), and (3) the northwest and central west coasts of Newfoundland (Plate I A). The more important physical features of each region are briefly described below.

Northeast Coastal Quebec

The coast in the vicinity of the Koksoak River mouth and north to George River has a low shoreline 5 to 9 kilometres distant from a low range of hills. Coastal waters are shallow for considerable distances seaward; small rock islands and partially submerged skerries (Plate IV B), often separated from the mainland by shallows that are dry at low tide, frequently parallel the shore. Extensive mud flats with scattered outcrops of light-coloured gneisses and granites dominate this area, and boulder ridges and outcrops of similar rock are more prevalent toward the northeast. Tidal amplitudes here are some of the highest recorded, spring tides at the mouth of the Koksoak River and False River Bay extending well over 13 metres, with even higher tides reported for the Payne and Leaf Bay districts to the northwest. Amplitudes decrease toward the tip of the peninsula, with spring tides up to 13 metres recorded for the mouth of George River and an average of only 6 to 8 metres for Port Burwell.

The coast from George River to McLelan Strait continues to be low and undulating, extremely dissected by bays and inlets. One of the most marked features of this region is the archipelago of small islands fringing the greater part of the coast. Coastal waters remain shallow, but in contrast to the broad mud flats of the southeastern part of the Bay, the shore is primarily of barren gneiss and granite outcrops or equally barren beaches of boulders and cobbles.

Five major rivers and numerous smaller ones discharge into lower Ungava Bay from the surrounding watershed. This immense discharge of relatively warm fresh water in areas with lesser tidal extremes would be expected to change the appearance of the marine intertidal zone to that of the shoreline of a fresh-water lake. Here, however, the tremendous influx of high arctic and subarctic marine waters into Ungava Bay from Foxe Basin, Hudson Bay, and the Labrador Sea offsets this dilution. Because of the geographic location of Ungava Bay and the interesting related hydrographic conditions, continued research in the marine phytoecology of its southern regions promises to be rewarding. Suggestions of the perhaps anomalous character of the flora of this region are seen in my collections from the southeastern and eastern shores of the bay.

Coastal Labrador

The coastline of southern Labrador along the north side of the Strait of Belle Isle is mostly sloping, often steep with occasional high headlands rising to 200 or 300 metres at the edge of the sea. Relatively low rolling land continues to Nain; north of this region a series of

coastal mountain ranges, the Kiglapaits, Kaumajets, and the Torngats, closely approach the shore, presenting an increasingly higher and more rugged appearance as they near the tip of the peninsula. Much of the coastline north of Nain is extremely bold and precipitous, the numerous towering cliffs at times rising to 600 metres from sea-level, and the long bays and fjords deeply indenting this shore sometimes have walls equally steep. The slope of the land is from east to west with the greater part of the eastern seaboard rising to considerable heights, contrasting with the undulating lowlands of the west side of the peninsula. Numerous coastal islands, which are separated from the peninsula and from one another by the deep narrow channels or "tickles" of the Newfoundland fisherman, shelter the mainland from the most severe seas.

Except for a relatively small portion of the north shore of the Strait of Belle Isle, the Labrador peninsula forms the eastern extension of the Canadian Shield and, as such, consists almost entirely of Precambrian rock. Granites and biotite gneiss in all possible combinations predominate, and schists and basic eruptive rocks appear to a lesser extent (V. Tanner, 1944). Occasionally one encounters scattered recognizable remains of metamorphosed sedimentary rocks in portions of the Kaumajet range and the vicinity of Cape Harrison, but by far the greatest part of the coastal rock is of the older type (R. Bell, 1884; Daly, 1902; Hantzsch, 1909; Tanner, 1944). In two small areas on the north side of the Strait of Belle Isle the Precambrian bed-rock remains covered by the Labrador series, depositions of sandstone in one region, limestone in another (Schuchert and Dunbar, 1934). Partly because of the nature of the rocks and partly because of the boldness and exposure of the coast, the littoral areas of sand and mud, so commonly seen in the lower regions of Ungava Bay, are rarely, if ever, encountered along the eastern coast of Labrador. The most sheltered areas of some inlets and fjords near the entrance of a stream or river constitute the only exceptions.

Whereas the tidal amplitude in Ungava Bay reaches a maximum of 14 metres, that at Nachvak Fjord on the Labrador coast is a little over one metre. This drop in the range of tide is rapid and occurs in the vicinity of the eastern entrance to the Hudson Strait (Tanner, 1944; Atlantic Coast Tide and Current Tables, 1954). More than any other single factor, the Labrador Current, flowing southward along the Labrador coast, produces the greatest effect on the life, both marine and terrestrial, of this area. Iselin (1932) describes this current as a cold-water stream that flows southward over the continental shelf inside the comparatively motionless homogeneous North Atlantic water.

According to Nutt (1956) the coastal and fjord waters during the winter remain virtually isothermal and isohaline with an average temperature of -1.78°C . at the coast and -1.76°C . in the inner fjords. Salinities at the same localities are 32.76 ‰ and 32.73 ‰ respectively. Summer temperatures of coastal waters remain low at depths greater than 30 to 40 metres, with salinities exceeding 31.00 ‰; above these depths surface warming and land drainage frequently raise water temperatures to 4°C . or more; salinities here are considerably less than 32.00 ‰ (Bailey and Hatchey, 1951; Nutt, 1952, 1956). The physical character of the water in the deeper bays and fjords presents an altogether different picture. As in

the case of the coastal waters the seasonal warming does not affect the temperatures of the deeper water, but here surface temperatures rise as high as 10°C.; salinities may be lowered to less than 20.00 ‰ (Nutt, 1952, 1956).

Northwest and Central West Coastal Newfoundland

Little time was available for the study of the flora of the western coast of Newfoundland; a few observations and collections were made while en route to the Labrador peninsula early in June, 1954.

The relatively undissected coast of western Newfoundland is approximately 600 kilometres long with a moderately low relief for some distance from the water's edge. The Long Range, forming the western shoulder of the inland plateau, rises abruptly from the coastal lowlands at varying distances from the sea, usually less than 37 kilometres. With few exceptions the rocks of the coastal region are lower Ordovician formations of light- and dark-coloured limestones with occasional outcrops of dolomite (Schuchert and Dunbar, 1934). The much older and ubiquitous granites and gneisses of the Labrador peninsula are nowhere exposed. Sand and gravel beaches are numerous, at times extending for considerable distances, but in general, much of the coast is flat shelving rock with many shallow tide pools. The appearance of the coast is considerably more hospitable than that of the regions to the north, which is further evidenced by the comparative ease of working in this area. The average tidal amplitude is small, even lower than that of the Labrador coast, ranging from one to slightly over two metres (Atlantic Coast Tide and Current Tables, 1954). During the winter, low water temperatures prevail in the Gulf of Saint Lawrence, and ice usually covers the entire area, while during the summer water temperatures are the highest of the three regions investigated. This great range of temperature and the totally different character of the coast (limestone as opposed to granite substrate, a flat coastal relief in contrast to the bold coasts of Labrador, and conditions that are less severe regarding exposure to ice movements) are such that comparative studies of this flora and those of the regions to the north and east would prove to be singularly important. It is in Newfoundland that the transitional marine flora between the subarctic and the cold-boreal regions of our coast is to be found. As a result of the Labrador Current the arctic-subarctic character of this flora extends much farther south than does the corresponding terrestrial flora.

LIST OF STATIONS VISITED

Newfoundland

1. Cooks Brook to Frenchmans Head, lat. 48° 59' to 49° 2' N., long. 57° 58' to 58° 9' W. The water of Humber arm in this region is strongly estuarial.¹ The littoral consists of sand and gravel beaches, which are replaced by shelving rock and cobbles toward the mouth of the estuary. Visited June 17-18, 1954.

¹Estuarial water is found in a bay or inlet which forms the lower end of a river, where tidal waters meet river currents with subsequent lowering salinity.

2. Port Saunders, lat. $50^{\circ} 40' N$. Collections were made in the area from the town to the entrance of the bay on the north side, which is partially exposed with the shore consisting of shelf rock and large cobbles. June 21, 1954.
3. Port-à-Choix, lat. $50^{\circ} 44' N$. The coastal area on the Gulf side of the peninsula is very much exposed, with the intertidal zone composed of continuous shelf rock and boulders with numerous shallow tide pools. June 21, 1954.
4. Brigg Bay, lat. $51^{\circ} 4' N$. This is a well-protected bay, in which the beach consists of cobbles and granite outcrops. June 22, 1954.

Labrador

5. Red Bay, lat. $52^{\circ} 32' N$. Collections were made along the north side of the harbour and northeast along the Strait of Belle Isle to Captains Cove. The inner bay is well sheltered from heavy seas and movements of ice. It has a shore of sand and gravel and is mildly brackish toward the head. The coastal areas are of cobbles and boulders with frequent rocky headlands, exposed except for scattered restricted areas. June 23-28. 1954.
6. Saint Francis Harbour Bight, lat. $52^{\circ} 32' N$. The harbour is well protected on all sides from seas or drift ice. The greater portion of the bay has a shoreline of steeply inclined rock walls and boulder beaches. June 30, 1954.
7. Packs Harbour, lat. $53^{\circ} 47' N$. The inner harbour is sheltered except from the east. The area between tide-marks is of unaltered rock and boulders. June 30, 1954.
8. Hopedale, lat. $55^{\circ} 15' N$. The region investigated was 7 to 9 kilometres in extent, located toward the northeast of the village of Hopedale along the moderately exposed coastal area of the outer bay. Outside the inner harbour, sheltered places are few and generally are very much restricted. The shore here is entirely of boulders or outcrops of banded gneisses. July 3, 1954.
9. Okak, near the old village, lat. $56^{\circ} 33' N$, long. $61^{\circ} 56' W$. The bay is a well-sheltered anchorage with steep sides toward the mouth, but with a more gently sloping shore of sand and gravel at the head of the bay. Dredging was done in water of from 16 to 20 metres depth, the bottom consisting of sand and silt with few rocks of any size. August 6, 1954.
10. Nutak Bay, near the village of Nutak, lat. $57^{\circ} 28' N$, long. $61^{\circ} 50' W$. The bay is long, narrow, and shallow with, for the most part, gently sloping shores. The littoral area consists of cobbles and boulders with increasing amounts of sand and gravel toward the inner bay. Dredging was carried out in water of from 4 to 8 metres depth, the bottom consisting of sand and silt with very little rock. August 6, 1954.
11. Amity Harbour, lat. $57^{\circ} 49' N$, long. $62^{\circ} 5' W$. This anchorage is well sheltered from the movements of ice and water except for the most severe weather with winds from the southeast. Dredging was done in water of from 14 to 18 metres depth, the bottom consisting of sand and small rock. August 8, 1954.

12. Kai-Kai Inlet, lat. $57^{\circ} 51' 5''$ N., long. $62^{\circ} 8-9'$ W. This narrow neck of water is almost completely surrounded by the steeply rising Kaumajet Mountains and thereby sheltered from the most severe weather. The shore consists of granitoid gneiss and talus fragments of sedimentary and volcanic origin (E. C. Abbe, 1936). August 8, 1954.

13. Napartok Bay, lat. $57^{\circ} 57-58'$ N., long. $62^{\circ} 35'$ W. Collections were made at the inner part of the quiet, well-sheltered northern arm of the bay. The shoreline is gently sloping with an intertidal zone of gravel and cobbles. Dredging was carried out in water of from 14 to 18 metres depth, the bottom consisting of sand and silt. August 16, 1954.

14. Hebron Fjord, lat. $58^{\circ} 5-10'$ N., long. $62^{\circ} 50-63' 5''$ W. Collections were made on the south and north sides. The portions of the fjord studied were usually enclosed by high tablelands with cliffs rising steeply from the edge of the water, or long, low, and rolling rock beaches with rock skerries to the fjord side and steeply rising terrain toward the inner part. The intertidal zone is similar to that of the longer bays and fjords along the coast. Many sand and gravel beaches occur at the head of the fjord, with cobbles, boulders, and rock outcrops, in that order, becoming common toward the open sea. Frequent dredging was carried out in water of from 4 to 24 metres depth, the bottom consisting of sand and scattered boulders, rock becoming more frequent at lesser depths. July 9-10, 14, 16, 29, 31, 1954.

15. Hebron Harbour, lat. $57^{\circ} 30'$ N., long. $60^{\circ} 40'$ W., immediately to the north of the entrance of Hebron Fjord. The harbour is sheltered at the mouth of the bay by a long low island. The surrounding coast consists of low rolling hills of bare gneiss with some boulder-clay terraces. The rocks of the littoral are of grey granite and gneiss streaked with a green schist and are well worn by the action of water and ice. Sand and gravel beaches are infrequent, occurring only in the most sheltered parts of the bay. Plants were dredged from water of from 4 to 24 metres depth, the bottom consisting of silt and cobbles in the deeper parts, but of shelving gneiss and rock debris in the shallows, July 6, 18, 26, 29, and August 1-2, 4, 12, 1954; October 1-30, 1955.

16. Watchman Island, lat. $53^{\circ} 13'$ N., long. $62^{\circ} 6' 5''$ W. This island is perhaps the most exposed of the Labrador coast. Few intertidal collections were made on the northwest side where there is little shelter except for the relatively small niches behind rocks and in small crevices. The littoral zone is often vertical, consisting of bold granite cliffs or small boulder-strewn beaches. Dredging was carried out in water of from 16 to 32 metres depth, the bottom consisting of shelf rock and scattered boulders. August 11, 1954.

17. Cape Morhardt, lat. $54^{\circ} 14' 6''$ N., long. $62^{\circ} 36' 5''$ W. Rising abruptly from the sea, the high coast in the vicinity of Cape Morhardt is very much exposed. The shore, where it is not vertical, consists of steeply sloping shelf rock and talus, with individual rock faces showing varying degrees of exposure to seas and drift ice. July 21-22, 1954.

18. Coast immediately south of Cape Uivuk, lat. $58^{\circ} 28' N.$, long. $62^{\circ} 34' W.$ This is an exposed coast consisting of bold cliff faces of granitoid gneiss cut by numerous diabase dikes, with beaches of boulders and other forms of talus. Except in the most restricted areas there is very little shelter. July 4, 1954.
19. Saglek Bay entrance, lat. $58^{\circ} 29' N.$, long. $62^{\circ} 44' W.$, south side near Cape Uivuk. The coast is exposed to the northeast with high, steep cliffs partially surrounding the area. The intertidal zone consists of outcrops of unaltered shelf rock or cobbles. September 29-30, October 14, 1955.
20. Eastern Harbour, lat. $58^{\circ} 31' 3'' N.$, long. $62^{\circ} 44' 6'' W.$ Littoral collections were made from well-sheltered areas toward the head of the harbour, to the southwest of Big Island. Plants were dredged from water of from 16 to 30 metres depth, the bottom consisting of sand and cobbles. The intertidal zone is primarily of various forms of granitoid gneiss. August 3, 1954; October 15, 1955.
21. Saglek Fjord, lat. $58^{\circ} 18' N.$, long. $63^{\circ} 36' W.$ Littoral collections were made toward the head of the southeast arm. The area is sheltered, with the shore consisting of sand and gravel. August 13, 1954.
22. Nachvak Fjord, lat. $58^{\circ} 6' 5'' N.$, long. $63^{\circ} 54' W.$ Very deep and steep-sided with two similar arms at the head, Nachvak Fjord is the most typical example of a classical fjord on the Labrador coast. Collections were made at the extreme head of each arm from sand and gravel strips which extended into the deeper water. August 15, 1954.
23. Kangalaksiorkvik Fjord (Seaplane Cove), lat. $59^{\circ} 25' 8'' N.$, long. $63^{\circ} 50' W.$ Collections were made at the entrance of the fjord on the north side in the littoral zone, which consisted of large boulders and cobbles. August 15, 1954.

Quebec

24. Port Burwell¹ (summer village and base camp, 1955), lat. $60^{\circ} 24' N.$, long. $60^{\circ} 24' 3'' W.$ This description includes a rather large area having broadly similar characteristics. The general vicinity of Port Burwell Harbour, at the head of Forbes Sound, is sheltered from severe weather except from the south and southwest. The coast consists of scattered headlands with steep sides interspersed with numerous bays and coves with equally precipitous sides. At the head of all but the most exposed of these indentations, however, there is a beach of gravel and cobbles with shoulders of unaltered rock. Although Jackson Island, on which my base camp was located, appears cut off from Killinek Island, during low spring tide it is possible to pass over protruding rock bars to the main island. Once there, one can walk overland to other regions of Killinek Island in spite of the exceedingly rugged terrain. August 16-17, 1954; July 12-August 25, 1955.

¹The village of Port Burwell at the turn of the century was inhabited by six to ten whites and as many as 60 to 80 Eskimos, but because of disease and migration to more civilized areas it now consists of six adult natives and four children.

25. Munro Harbour, lat. $60^{\circ} 26' 6''$ N., long. $64^{\circ} 52' 8''$ W. This harbour is a long narrow shallow bay with steep sides. Only the entrance to the bay is exposed, and then only to weather from the west and northwest. At the northeast side of the mouth of the harbour, the littoral and sublittoral are primarily of shelving rock scattered with loose rock fragments from the sides of the bay. August 3, 10, 1955.

26. Fox Harbour, lat. $60^{\circ} 25'$ N., long. $64^{\circ} 47-51'$ W. The outer portion of the harbour is exposed to seas from the northwest and to the movement of ice. The harbour is long and narrow with the southwest shore of high granite cliffs and some sedimentary rock. The land to the northeast is much lower, with the beach composed of various types of metamorphic rock with occasional smaller promontories of granite. At three-quarter tide level, water and to some extent ice-masses from outer Forbes Sound move into the inner sound (Mission Bay) by a narrow neck of water connecting Mission Bay with the head of Fox Harbour. August 5-6, 17-18, 1955.

27. Nanook Pool, lat. $60^{\circ} 25'$ N., long. $64^{\circ} 50' 8''$ W. This broad but deep rock pool is located between Fox Harbour and Mission Bay. The bottom consists of sand, scattered cobbles, and boulders. The entire pool is thoroughly sheltered. August 5-15, 17-18, 1955.

28. Mission Cove, lat. $60^{\circ} 25' 2''$ N., long. $60^{\circ} 50' 8''$ W. A long bay located at the head of inner Forbes Sound, Mission Cove is moderately deep with steep rock sides, except for the inner northeast shore, and is completely sheltered from severe seas and movements of ice. The littoral, except for some sand and gravel at the head of the cove, consists of boulders and talus. August 5-6, 17-18, 1955.

29. Region immediately south of Mission Cove (between Mission Cove and Port Burwell), lat. $60^{\circ} 25' 5''$ N., long. $64^{\circ} 50' 9''$ W. This area of the northwest corner of inner Forbes Sound is well sheltered except from the southwest, storm waves being only occasionally encountered. The coastal waters are mainly shallow, and one must pass for considerable distances out into the sublittoral before depths greater than 30 metres are attained. The shore is of sand and shelving rock with numerous shallow tide pools. August 5-6, 17-18, 24, 1955.

30. The vicinity of Port Harvey, northern Killinek Island, lat. $60^{\circ} 28' 5''$ N., long. $64^{\circ} 41' 4''$ W. In much of this area the beach is protected from the most severe weather by numerous offshore islands and submerged reefs. The intertidal zone is rarely other than steeply inclined rock surfaces, but occasional rock and boulder beaches occur at the head of shallow coastal indentations. The tides and currents in this vicinity are extremely rapid and are set up as a result of the unequal tides on the east and west sides of Killinek Island. August 7, 1955.

31. McLelan Strait (Grenfell Tickle), lat. $60^{\circ} 21' 5''$ N., long. $64^{\circ} 42'$ W. Collections were made at the first narrows near the western entrance. McLelan Strait is a narrow channel of water, 1,000 metres in width and approximately 19 to 20 kilometres long, separating Killinek Island from the mainland. The shores of the strait rise abruptly from the water; the littoral areas are mostly steep cliff faces of granite and gneiss, or at

times of fallen rubble of similar material. Tidal amplitudes average $6\frac{1}{2}$ metres on the Ungava side and a little more than 3 metres at the east entrance, the resulting difference in water levels forming a current which may be 10 knots or more. (The movement of the early summer ice with this current through the strait during a spring tide is truly a spectacular sight.) July 18–20, 1955.

32. Numerous stations between lat. $58^{\circ} 22'$ and $60^{\circ} 21' N.$ Collections and observations were made en route from Fort Chimo to the tip of the Labrador peninsula, but due to the state of the ice and the means of travel, rarely could a definite location be determined. The precise positions of the stations in this area are unknown, and they are therefore listed as "Ungava Bay, northeastern Quebec." July 7–20, 1955.

33. False River Bay, at the head of the bay, lat. $68^{\circ} 25' N.$, long. $67^{\circ} 58' W.$ The littoral zone is composed of expansive boulder-strewn mud flats and occasional gravel and cobble beaches. The greater portion of this region of the bay is sheltered from the destructive environmental forces. September 4–5, 1955.

34. False River Bay, near the mouth on the west side, lat. $58^{\circ} N.$, long. $67^{\circ} 45' W.$ The shore in the intertidal zone is a continuation of the coastal bed-rock. It consists of low and rolling, unaltered, well-smoothed, light-coloured granites, with patches of mud in the rock depressions. September 3–6, 1955.

35. Koksoak River mouth, lat. $58^{\circ} 31' 5'' N.$, long. $68^{\circ} 10' W.$ The Koksoak River is broad with treacherously deep and swiftly flowing waters. Only the most restricted rock surfaces provide shelter from ice and water currents. The peripheral coastal areas are of barren light-coloured granites or broad mud flats. August 21, 1954; July 7, September 3, 6, 1955.

36. Koksoak River, at the narrows, toward the mouth, lat. $58^{\circ} 20' N.$, long. $68^{\circ} 12' W.$ The intertidal zone consists of steep, well-smoothed rock, occasionally with less extreme areas of boulders and cobbles found in sheltered depressions. The sides of the river channel in this area are continually exposed to the abrading forces of moving water, ice, and debris of all types. June 27, 1955.

37. Fort Chimo, at the village, lat. $58^{\circ} 10' N.$, long. $68^{\circ} 14' W.$ The shore and the sublittoral fringe consist of barren, light-coloured granites and gneiss or of rock-strewn expansive mud flats (Plate V, figure 2). The latter are found only in the regions of backwaters or in areas where the river is less turbulent. August 20–22, 1954; June 8–10, September 1, 1955.

38. Frobisher Bay, Baffin Island, in the vicinity of the native village, lat. $63^{\circ} 35' N.$, long. $65^{\circ} 30' W.$ The coast consists of low rolling hills with the upper shore of granite-gneiss outcrops or of boulder beaches. At the time of my visit the ice-mass was unbroken except for tidal cracks and occasional small holes near the shore. May 30–June 4, 1955.

GENERAL ECOLOGICAL CONSIDERATIONS

Since the time of Kjellman's studies on the algal vegetation of the Murman Sea (1877) and of the Skagerrack (1878), which probably are the bases of our modern methods in marine ecology, our knowledge in this field has been greatly advanced. Many, such as Cotton (1912), Johnson and Skutch (1926), Gislén (1930), Bell and MacFarlane (1933), Feldmann (1937, 1951), T. A. and A. Stephenson (1939, 1944, 1949, 1954), Chapman (1946), Evans (1947, 1949), and Bernatowicz (1952, thesis unpubl.), have contributed to the understanding of marine plant ecology in various parts of the world. Many schemes have been proposed for classifying habitats and the relationships of plants to their environment. With reference to this great diversity of systems, Bernatowicz (*loc. cit.*) aptly comments, "There has been a chaotic lack of unanimity both in the names applied to many of the categories and in the degree to which any category has been subdivided."

For the purposes of this study I have adopted a composite of the existing systems of habitat classification. Each habitat is classified according to its physical characteristics rather than by the peculiarities of its vegetation.

It is not my purpose to review here the different opinions that have been offered concerning various ecological concepts pertaining to marine algae. It will, however, be convenient to state which ecological terms will be used in this study and to define their usage. The term "zone" applies to the major horizontal regions of the coast or of a particular marine habitat. There are two zones, littoral and sublittoral, which may at times be subdivided into upper, lower, and mid-regions of each zone. There may exist one or more "belts"¹ of vegetation, which at times are characteristic of the particular zone or region of a zone. A "belt," as I will define it, may consist of an aggregation of two or more species (a community) which may have a constant horizontal relationship relative to the shore. In any community it is possible that several species, which are consistently found together and rarely found disassociated, may be present. To these the more restricted term "association" is applied. When describing habitats, my use of the term "exposure" is restricted, referring to the degree of wave action or, where specifically stated, to the amount of sunlight or ice movement.

Five major types of habitat can be distinguished on the basis of degree of exposure to wave action, movements of ice, and intensity of light; closely correlated with these factors are the type of substrate and the salinity of the water at each station. These habitats are termed as follows: (1) mud flats, (2) protected shallows, (3) moderately exposed coasts, (4) fully exposed coasts, and (5) tide pools.

Subdivision of the shore in each habitat distinguishes a continuously submerged zone, the "sublittoral," from the "littoral," a region periodically exposed by receding tides. The littoral zone comprises the intertidal region proper, its lower limit marked by the extreme low water of spring tides.

¹For Feldman (1951) the term "belt" was all-inclusive, the vegetation of any habitat occurring in four belts: the supralittoral, the littoral, the infralittoral, and the lower infralittoral.

The upper limits of this zone are less definable but may extend considerable distances above the highest recorded tides in any particular area, depending upon the amount of splash and spray and the roughness of the rock surface. Thus, the littoral zone, as I consider it here, includes the "spray zone" or "supralittoral" of some investigators, for in the North these two zones are hardly distinct. The term "spray zone" will be used, however, to denote the uppermost parts of the shore.

The sublittoral includes all the coastal area below the limits of low spring tides. I see no reason to distinguish in this investigation the lower "elittoral"¹ as separate from the sublittoral as did Kjellman (1883), Feldmann (1937), and others. Following Feldmann (1937) and Womersley (1947), I have distinguished the upper part of the sublittoral (approximately 5 metres, as the "upper sublittoral," which is not to be confused with the "sublittoral fringe"² of Stephenson (1939).

Since field observations reveal a close relationship between plants and environment, it is possible to characterize each habitat by the nature of its vegetation as well as by its physical environment. Diversity in composition and configuration of substrate and in the degree and duration of insolation usually determines which genera and species appear in the vegetation, whereas different depths and degrees of wave action and changes in salinity effect specific differences between communities and produce polymorphism within species (Plate XI A and B). Whether the common occurrence of polymorphism is due to ecological variation with no genetic basis or to genetic forms which occupy specific ecological niches as a result of natural selection, is unknown to me. In many instances, however, the widespread occurrence of intermediate algal forms found within restricted habitats of varied exposure indicates strong tendencies of ecological variation. This is even more plausible if it is considered that with all of the discharged zoospores or gametes from a single sporangium or gametangium subject to waves and currents, it is not inconceivable that the distribution of these cells ranges from the high littoral tide pools to rock niches of the sublittoral. If, then, large numbers of cells, genetically similar if from a zoosporangium, discharged from a single reproductive structure, ultimately develop into widely different morphological forms, it is not likely that this diversity is a result of natural selection. Much work remains to be done before this hypothesis has more than an empirical basis. Listed below are some of the species, found throughout the area in totally different habitats, which exhibit extreme polymorphism: *Ulothrix flacca*, *Spongomorpha arcta*, *Chordaria flagelliformis*, *Petalonia fascia*, *Laminaria nigripes*, *Fucus distichus*, *Halosaccion ramentaceum*, and *Rhodymenia palmata*. A tabulation of such species by themselves reveals little concerning the nature of the particular habitat from which they were collected. It does seem clear to me however, that it will be possible on concluding this study and others, to apply varietal and form names consistently in a manner to conform with the ecological conditions under which the plants grew.

¹The region of the bottom below 36.5 metres which supports an algal vegetation.

²This is a more restricted term applying only to the region of the shore between mean low water of neap tides and extreme low water of spring tides; in New England and the Maritime Provinces it is essentially a zone of fucoids and kelps.

A detailed discussion of seasonal periodicity in the plant communities of the areas investigated cannot be attempted on the basis of the present study. Nor are there at this time sufficient data to permit a thorough comparison of the vegetation of northern Labrador with that of southern Labrador. Comparisons will be made primarily between the algal communities of the three general areas of the northern part of the Labrador peninsula where the greatest amount of time was spent (vicinities of Hebron and Hebron Fjord, Port Burwell, and the mouth of the Koksoak River). Discussion of seasonal periodicity will be restricted to these areas. Although the total length of time I spent at any of the stations represents only a small part of the year, my visits were during the months when one may observe the most critical changes in the algal flora of this region.

The seasonal changes of the algae in the coastal waters of northern Labrador are considerably less marked than those occurring in marine areas to the south. Moreover, only a small fraction of the flora is involved, and only those phases of their periodicity that appear during the short ice-free period may be observed. During this investigation only a few annuals could be observed throughout their entire growth season. Portions of the life cycle of others were studied, and their probable life-span was estimated by the condition of the plants and the time of year that they were collected.

There are few differences in the number of species between the three major areas referred to above, but the frequency of some of these species seems to vary from one region to the other. For example, in the vicinity of Port Burwell one may observe large populations of *Laminaria groenlandica*, *Laminaria solidungula*, *Dilsea integra*, *Polysiphonia arctica*, and other plants I consider to be arctic species. At Hebron the same species, although present, may be represented in smaller numbers and found in deep water only. A comparable situation exists with regard to the presence of boreal species *Enteromorpha erecta*, *Enteromorpha plumosa*, *Percursaria percursa*, and *Ectocarpus confervoides* in the vicinity of the Koksoak River mouth, in contrast to their absence or infrequent occurrence at Port Burwell and Hebron.

The few investigations of arctic marine vegetation in the past, almost without exception, were primarily concerned with taxonomic and morphologic aspects of the plants. Practically none of these studies dealt with the relationships of the algae to each other and to their environment. Of the little work of this kind that has been done, most notable are the studies of Kjellman (1877, 1878, 1883, 1886), Jónsson (1912), Børgesen and Jónsson (1905), E. S. Sinova (1922a, 1922b, 1929), and Lund (1954). Of these workers, only Kjellman remained for considerable periods of time in the arctic studying marine algae. After spending the winter of 1872-73 on the north coast of Spitsbergen, visiting other arctic regions for shorter periods of time, and examining specimens collected by others from still different parts of the arctic, he was of the opinion that "... there are not to be found among the sublittoral and elittoral algae of the arctic flora any species whose whole development is limited to less than one year." He further states "... there is yet no sure evidence for the existence of annual species among the arctic algae"; thus Kjellman also excludes the presence of annuals in the area between tide-marks. Unless ecological conditions in the marine environments of the higher latitudes differ grossly

from those I have encountered in northern Labrador, it is difficult for me to believe that Kjellman could have overlooked or misinterpreted the striking examples of seasonal periodicity that must have occurred during the time of his field work.

During the course of the eight months I spent in the field, I was able to witness the "seeding-in" and subsequent development, and more rarely the senescence, of a number of plants that may be referred to as annuals. Examples of these are listed below:

Ulothrix flacca

Enteromorpha compressa

Enteromorpha intestinalis

Enteromorpha micrococca

Monostroma fuscum

Spongomorpha arcta

Pylaiella littoralis

Chordaria flagelliformis

Elachistea fucicola

Porphyra miniata

Striking changes in the appearance of the shore vegetation result from the periodic development of these plants and others, which primarily occur in the littoral zone. No attempt will be made to discuss the seasonal periodicity, if it exists, of the vegetation of deeper waters. There are, however, several unrelated species found in the littoral and sublittoral, which persist throughout the year and exhibit seasonal tendencies for growth. They apparently remain viable for periods of more than one year but for less than two years. For plants of this nature Gislen (1930) uses the term "herbaceous perennials," the so-called 'leaves' of the plants being shed each winter with a frequently well-worn and reduced thallus remaining to over-winter. Of these species very little may be said regarding the duration of their life span. I must admit, however, after seeing the number of plants in the high sublittoral and littoral zones after the spring break-up, that there are many algae of this nature, in addition to the better known perennials, which persist for longer periods of time. In the spring and early summer these 'biennials,' although commonly denuded of most of the smaller branches, soon begin a vigorous development, producing new growth, which forms a striking contrast to the older branches of the first-formed thallus. Several examples of such species are *Chordaria flagelliformis*, *Stictyosiphon tortilis*, *Ahnfeltia plicata*, *Halosaccion ramentaceum*, *Polysiphonia arctica*, *Rhodomela confervoides*, and *Rhodomela lycopodioides* f. *flagellaris*.

Other species, of unknown number, begin their growth late in the autumn or even after the freeze-up and develop considerably by the time the ice has departed the following year. Although development under the ice must occur at a relatively slow rate, this growth probably promotes early maturation of the plants the following spring. Soon after the spring break-up, for example, I have seen mature or almost mature plants of a considerable number of species producing their fruiting structures and releasing their reproductive cells. Subsequently, these plants become heavily epiphytized and eventually torn from the rocks. Notable examples of this type of development are *Chaetomorpha melagonium* and *Dilsea integra*, both of frequent occurrence in the upper sublittoral early in the summer with almost every plant in a late stage of its reproductive cycle.

MUD FLATS AND ASSOCIATED HABITATS

Mud flat habitats are infrequent in the area investigated, and they are seen only in the southwestern and southeastern regions of Ungava Bay and occasionally near the entrance of fresh-water streams at the heads of bays and fjords on the northeastern Labrador coast.

As a result of the enormously high tides, the low relief of the surrounding watershed, and the tremendous discharge of silt from the large rivers and streams, the intertidal areas of lower Ungava Bay take the form of expansive mud flats. Elsewhere in the bay, the shore commonly consists of rock. At extreme low tide these flats may extend for considerable distances back from the water and a kilometre or so along the coast, unbroken except for scattered outcrops of rock, which, with the cobbles and shingle exposed by tidal runoff, form two additional algal habitats associated with mud flats (Plate V B).

Silt covers the entire littoral area and presumably extends well into the sublittoral; in most places it is deposited to a depth of but a few inches, but in depressions and crevices it frequently accumulates to one metre in thickness.

Ecological Factors in the Littoral Zone

The effect of environment on the aspect and composition of the flora is perhaps more obvious in the mud flats than in any other habitat observed. Because of adverse environmental conditions the flora here is scanty, smaller in size, and uniformly monotonous throughout much of the ice-free season, whereas similar habitats farther south often manifest a much larger and more diversified flora.

Emersion. Portions of the intertidal zone in the Ungava Bay region remain exposed for considerable intervals of time. Desiccation during emergence, although significant in some marine environments, apparently becomes less important toward the north where, because of high relative humidity during the summer months, desiccation occurs slowly. It is suggested that a more important factor affecting the growth and development of summer annuals in arctic and subarctic regions is the temperature of the air, which may be quite low early and late in the ice-free period.

Substratum. One of the most significant physical factors affecting the growth of marine algae is the nature of the substratum available for algal colonization. Areas in which the 'bottom' consists of loose, unconsolidated material, offering little substantial anchorage for plants, lack all but the smallest algae; these are usually turf-forming annuals.

Salinity. Although in some areas of the Arctic, reduction of salinity is of importance to the growth of marine plants, in all the areas visited in southern Ungava Bay, at least along the outer coastline, it was not significant. Even at the mouths of the larger rivers flowing into the bay, salinities do not decrease to such an extent that typical marine intertidal species can not be found attached to rocks where they are exposed.

Movements of Ice and Water. Second to the nature of the substratum, I consider the most significant factor affecting the growth of algae on mud flats to be the movement of coastal waters and the prevalent ice-masses, which not only devastate the algae of the intertidal zone but also may alter or even remove the underlying mud. Only the occasional rock formations permit a meagre perennial vegetation.

Vegetation of Mud Flats

Mud flats are botanically quite distinctive and are easily studied because of the prevailing uniformity of the habitat and the few species that constitute the vegetation, although these may be abundant. Representative stations were visited shortly after the ice went out in 1955 and during the autumn of 1954 and 1955; the algal turf was completely absent during the early part of the year and was fully developed later in the season. The components were all annuals, reaching their peak of development through late August and early September. Perennials are lacking, probably because of the instability of the mud. The turf covering the surface of the mud consists primarily of *Vaucheria sphaerospora*, *V. submariana*, and *V. compacta*, with *V. sphaerospora* being dominant throughout the community.¹ With the species of *Vaucheria* are *Urococcus foslieanus*, *Codium pusillum*, *Gloeocystis scopulorum*, *Calothrix scopulorum*, and other species of blue-green algae. Together they form a dense turf which slightly penetrates the mud and becomes infiltrated by it, while the entangling of the plants consolidates the turf itself. This algal turf is dark green, almost black when moistened, at which time it becomes extremely slippery.

Vertical distribution within the intertidal zone seems to depend on the presence and the amount of mud, species of *Vaucheria* flourishing throughout the littoral area and at times extending below low tide.

Vegetation of Other Littoral Habitats Associated with Mud Flats

Two additional intertidal habitats are found associated with mud flats. One of these is formed by scattered rock outcrops and boulders, small stable islands in the broad expanses of unconsolidated mud and silt. The most sheltered niches of such habitats support worn and meagre populations of the perennial species *Fucus vesiculosus*, *F. distichus*, *Ascophyllum nodosum*, and *Ralfsia fungiformis*. In niches well shaded by overhanging fuci are found equally impoverished plants of *Hildenbrandia prototypus* and *Rhodochorton purpureum*, which lack the pigmentation of the more robust ones found lower on the shore. The other habitat associated with mud flats is formed wherever streams of fresh water, or more frequently, streams of tidal runoff dissect the shore. In such instances the mud and sand are partially or entirely removed, exposing the pebbles and cobbles, which from late July through September support rich populations of a few species of annuals, most of which can also be found attached to the

¹All species of *Vaucheria* were identified by Dr. J. L. Blum, Department of Biology, Canisius College, Buffalo, New York.

bases of the larger rock outcrops. With the exception of *Rhodomela confervoides*, these annuals are small members of the Chlorophyceae and Phaeophyceae, most common of which are *Enteromorpha intestinalis*, *Eudesme virescens*, *Chordaria flagelliformis*, *Petalonia fascia*, and *Chorda tomentosa*.

The following tabulation includes all the species and varieties found in the mud flats and associated littoral habitats. Those designated by an asterisk were common as drift, though unobserved in the attached condition.

MYXOPHYCEAE

<i>Calothrix scopulorum</i>	<i>Lyngbya</i> sp.
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XANTHOPHYCEAE

<i>Vaucheria sphaerospora</i>	<i>Vaucheria compacta</i>
<i>Vaucheria submarina</i>	

CHLOROPHYCEAE

<i>Gloeocystis scopulorum</i>	<i>Enteromorpha micrococca</i>
<i>Urococcus foslieanus</i>	* <i>Enteromorpha plumosa</i>
<i>Ulothrix flacca</i>	* <i>Monostroma fuscum</i>
<i>Capsosiphon fulvescens</i>	* <i>Percursaria percursa</i>
<i>Enteromorpha intestinalis</i>	<i>Prasiola crispa</i>
f. <i>clavata</i>	
* <i>Enteromorpha marginata</i>	<i>Cladophora glaucescens</i>

PHAEOPHYCEAE

<i>Ectocarpus confervoides</i>	<i>Ralfsia fungiformis</i>
<i>Ectocarpus siliculosus</i>	<i>Elachistea fucicola</i>
<i>Pylaiella littoralis</i>	<i>Chordaria flagelliformis</i>
<i>Eudesme virescens</i>	<i>Chorda filum</i>
* <i>Isthmoplea sphaerospora</i>	<i>Chorda tomentosa</i>
<i>Petalonia fascia</i> var.	<i>Ascophyllum nodosum</i>
<i>zosterifolia</i>	<i>Fucus distichus</i> subsp. <i>evanescens</i>
<i>Petalonia fascia</i> var.	<i>Fucus vesiculosus</i>
<i>caespitosa</i>	
<i>Scytosiphon lomentaria</i>	

RHODOPHYCEAE

<i>Rhodochorton purpureum</i>	* <i>Rhodomela confervoides</i>
<i>Hildenbrandia prototypus</i>	

Ecological Factors in the Sublittoral Zone

Observations and collections of the attached plants from deep water could seldom be made. A few observations were made from open native boats too small for dredging of any kind. Therefore my knowledge of the continually submerged plant communities in this region comes mainly from

the study of drift plants. Each year during the spring and autumn, immense quantities of algae are torn loose by the strong currents, heavy seas, and ice, making it possible to determine quite accurately from drift the composition of this flora. It is not uncommon to find included in the drift-weed excellent specimens of coralline algae cast from habitats of considerable depths. Although it is improbable that all the deep-water calcareous forms were collected, a higher percentage of species than previously known for the area, as well as a number of new records, was returned to the laboratory for study.

The chief environmental factors producing the distinctive growth of sublittoral algae in this region are substratum, water currents, and the movement of ice.

Substratum. The bottom is generally plane, interrupted by frequent skerries and masses of rock, which may be partially exposed at low tide. Although the greater part of the bottom remains soft, the frequent patches of rock provide the necessary anchorage for the immense populations of kelp found in this region.

Water Currents. From my own observations and information obtained from the few existing charts of this region of Ungava Bay, it appears that the water remains shallow for considerable distances seaward. Strong currents are characteristic of lower Ungava Bay, although water movements of equal and greater velocity can be found elsewhere in the bay where, because of local constrictions in the many narrow water channels, treacherous tide-rips are formed. Whenever present, rapid smoothly-flowing water appears to stimulate algal development, resulting in plants of great size. These water conditions were also encountered in the region of McLelan Strait and in some of the narrow fjords of the Labrador coast.

Movements of Ice. The movements of ice are less destructive in deep water than in the littoral zone, with only the upper portion of the former being affected by the largest ice-masses. There is little doubt, however, that considerable damage to the plants of this zone is effected by storm waves and moving ice-floes.

Vegetation of the Sublittoral

The vegetation here is completely dominated by large populations of *Agarum*, *Laminaria*, and *Alaria*. The individual plants of these and other genera frequently are of immense size; nowhere else were plants so large and bulky encountered, except for occasional ones at certain other stations, notably the region of McLelan Strait, and as drifting plants elsewhere. The algal undergrowth is not only abundant but luxuriant, characterized by a number of leafy red and green algae attached to the bases of the kelps. Such species as *Pantoneura baerii*, *Phycodrys rubens*, *Membranoptera denticulata*, *Odonthalia dentata*, *Rhodymenia palmata*, and *Monostroma fuscum* are common, whereas *Phyllophora interrupta* and *Kallymenia schmitzii* (Plate X B), although less frequent, may form dense masses of

detached or loosely attached plants in deeper quiet waters, or grow attached to rocks and kelp in other regions of the sublittoral. A complete list of the species I found as drift from this zone follows. The most abundant species are designated by an asterisk.

CHLOROPHYCEAE

Chlorochytrium schmitzii
**Monostroma fuscum*

Chaetomorpha melagonium
Cladophora glaucescens

PHAEOPHYCEAE

**Pylaiella littoralis*
Ectocarpus dasycarpus
Ectocarpus fasciculatus
Chaetopteris plumosa
**Desmarestia aculeata*
**Alaria grandifolia*
Laminaria groenlandica
**Laminaria longicruris*
**Laminaria nigripes*

Isthmoplea sphaerospora
Stictyosiphon tortilis
Litosiphon filiformis
Dictyosiphon foeniculaceus
Agarum cribrosum
**Laminaria solidungula*
**Laminaria* sp.
Saccorhiza dermatodea
Fucus distichus subsp. *evanescens*

RHODOPHYCEAE

Porphyra miniata
Rhodochorton penicilliforme
Dilsea integra
Euthora cristata var. *angustata*
**Kallymenia schmitzii*
Rhodophyllis dichotoma f. *setaceae*
Ahnfeltia plicata
Phyllophora brodiaei
Phyllophora interrupta
Halosaccion ramentaceum
Rhodymenia palmata

**Antithamnion boreale*
Ptilota serrata
Membranoptera alata
Membranoptera denticulata
**Pantoneura baerii*
**Phycodrys rubens*
**Odonthalia dentata*
**Polysiphonia arctica*
Polysiphonia urceolata
**Rhodomela confervoides*

Periodicity

Several months elapsed between my few short visits to mud flats. As a result, my knowledge of the changes in composition of the algal communities found there is restricted to an understanding of static phases of the vegetation. We may infer the succession of seasonal changes by comparison of these communities with others of similar nature.

The details of the development and senescence of the *Vaucheria*-Myxophycean turf are lacking. It may be that in areas to the south some species of *Vaucheria* possess a vegetative overwintering stage, but in the north they must be considered as obligate annuals, being completely absent even from the most sheltered places in the early spring. Feldmann (1937) has suggested that *Vaucheria piloboloides* survives the winter by means of dormant reproductive structures and has referred to this type of annual as a "hypnophyte." The *Vaucheria* species inhabiting mud flats in

the North may then by necessity fall into the category of 'obligate annuals' as a result of the effect of both the environment and the latitude. It would seem from the study of material collected in northern Quebec in 1954 and 1955 and from some of the same species from the northern tip of Newfoundland in 1957, that fruiting is partially dependent upon latitude. The plants collected from the more northerly locality were fruiting abundantly during August and September, but no evidence of fruit was apparent at approximately the same time on the plants from Newfoundland.

Late in June, 1955, a short visit to the mud flats near the mouth of the Koksoak River enabled me to see that, after the ice left, the boulders and rock outcrops were clothed only with torn and battered perennials. During visits in late summer and autumn (August, 1954, and September, 1955) these rocks bore a fully developed vegetation, at that time largely consisting of phaeophycean annuals. From my observations of these habitats and from more detailed and lengthy studies of other habitats on the Labrador peninsula, I conclude that the annual lithophytes of the mud flats, with few exceptions, make their appearance toward the middle of July and reach their peak of development by the first week in September.

PROTECTED SHALLOWS

At the heads of long well-protected coves, bays, and fjords there are quiet, usually shallow areas with generally undissected shores. These regions may be classed as a major type of habitat, which will be referred to as 'protected shallows,' although they pass gradually into the moderately exposed coast. The heads of some quiet inlets, as Fox Harbour, are narrow, the width of a small stream; others vary in width from 50 to 100 metres (Plate V A).

The rivers and streams, which once flowed to the sea along the floors of now submerged valleys, discharge their waters and sediment into the heads of these fjords and bays. At the innermost part of the bay, the land immediately above high water-level supports a substantial heath vegetation not seen in the outer maritime regions exposed to the drying coastal winds. The upper marine environment, however, is extremely inhospitable to salt-water plants, mainly because of the large amounts of fresh water that periodically empty into these shallows with relatively slow replacement by more saline water from the coast, and because of the crushing and scouring action of the ice (Plate IV B).

Typically shallow with gently rising shores, most of the bays visited vary in depth from 2 to 10 metres at their heads. The shore, similar in some respects to the mud flats, occasionally consists of irregular patches of sand and mud with varying amounts of rock. The upper littoral may be merely a continuation of the intertidal cobbles and shingle, or in some instances it is sharply defined from the region immediately above it by a fringe of large boulders or exposed surfaces of shelving rock. Continuing from the shore as soft, unconsolidated sand and mud with small scattered rock, the bottom is commonly flat, interrupted by larger masses of rock.

Ecological Factors in Protected Shallows

Emersion. The tidal range varying from 1 to 13 metres results in a great variation in the width of the intertidal zone in bays at various points along the peninsula. Algal communities, where they exist in the littoral, consist of plants that are tolerant of wide changes of salinity (euryhaline species) and long periods of emersion and submersion; however, even the most adapted of these plants must be sheltered from the destructive movements of ice in order to survive.

Insolation. Except for the shade afforded by rock niches and by members of the Fucaceae and occasionally the Laminariaceae, there is little shelter from the direct rays of the sun. Rhodophycean algae are almost totally excluded from this community chiefly because of the intensity of sunlight, which is little reduced by the gradual slope of the shore and the shallowness of the bay.

Substrate. The shores and bottom of quiet bays, consisting of large areas of sand and mud with scattered rocks, are generally unsuited for attachment of larger algae.

Salinity. Reduction of salinity of the water at the heads of quiet inlets is the most significant ecological factor regulating the growth of marine algae. During a part of May, June, and July great volumes of fresh water from melting ice and snow flow over the heavier sea water in the bay, and the water mass remains stratified in this way. The seasonal influx of fresh water through May and June, which, according to Nutt (1956), represents 80 per cent of the precipitation, freshens and raises the temperature of the surface layers of fjords (e.g., Hebron Fjord) to a depth of 80 to 100 metres. This is the primary reason for the lack of marine life in the littoral and upper sublittoral zones of the relatively quiet bays and fjords. Many such areas, being almost completely devoid of algae, have the appearance of a fresh-water lake shore during the early summer. Below 100 metres, fjord water is little affected, showing salinities of more than 32.00 ‰ and summer temperatures of -1.00°C . at 100 metres and as low as -1.68°C . at 225 metres (Nutt, loc. cit.).

Wave Action. Storm waves are never encountered in this protected environment; water movements are limited to surface agitation and the gentle swells of deeper water. At most, the choppy surface movements may throw spray a few inches above the level of high spring tides. Absence of the typical coastal water movement, as it affects salinity, limits the type and number of species in the protected shallows. Increasingly large numbers of species, including the larger brown algae, are encountered as the open coast is approached. As wave-action becomes heavier, salinities approximate those of the coastal waters and the bottom in the littoral, and much of the sublittoral is much more favourable for algal attachment. These changes in environment occur gradually and produce no abrupt shift in vegetation, but rather a corresponding transition between that of the protected shallows and of moderately exposed coasts.

Movements of Ice. In quiet bays and fjords, ice is formed early in the autumn, developing during the winter to a thickness up to 4 metres. Remnants of this ice, the ice foot or "sina" (Plate IV A) may remain, covering much of the intertidal zone until late in July or in some years August. When drifting ice is present, it rises and falls with the tide, crushing any plants exposed.

Vegetation

From a floristic standpoint, protected shallows are distinguished by a dearth of species, which, however, exist in large populations. Small chlorophycean and phaeophycean annuals constitute the majority of the species, while a few perennials, usually *Ascophyllum nodosum*, *Fucus distichus* subsp. *evanescens*, and *F. vesiculosus*, form the bulk of the vegetation. Smaller perennials of importance are *Ralfsia fungiformis* and *Rhodochorton purpureum* and, where the bay is deep and dilution by fresh water is slight, *Chordaria flagelliformis*, *Desmarestia aculeata*, *Petalonia fascia*, *Scytosiphon lomentaria*, *Dictyosiphon foeniculaceus*, *Chorda filum*, *C. tomentosa*, and other annual species also appear. Where salinities are lowest, however, even the ubiquitous fuci are absent, the vegetation here consisting only of several freshwater-tolerant chlorophycean annuals and a myxophycean crust.

The algal community of protected shallows can be subdivided into three groups of plants as follows: (1) an assemblage of small perennials and summer annuals, (2) the *Fucus* association, and (3) the *Calothrix* association. The first two groups occur in both the littoral and sublittoral, while the *Calothrix* association is confined to the upper intertidal area.

Littoral Algae. Plants making up the communities of perennials and summer annuals are mostly attached to the intertidal rocks. A few annual species appear soon after the spring break-up, but most arrive late in the summer, reaching their peak of development in September and October. Some of the species that begin their development early in the spring and summer, and perhaps live through much of the ice-free period, are *Ulothrix flacca*, *Enteromorpha intestinalis*, *Monostroma fuscum*, and *Pylaiella littoralis*. These species were collected at the submerged mouths of freshwater streams, although *Monostroma* was not common under these extreme conditions, appearing more frequently where salinity was higher. *Enteromorpha*, *Ulothrix*, and *Pylaiella*, seemingly far more tolerant of fresh water, may usually be found wherever rock is present. *Enteromorpha* and *Ulothrix* are generally limited to the upper littoral zone. *Pylaiella*, growing both on rocks and as an epiphyte on fucoids, occurs throughout the intertidal zone and extends far into the deeper offshore water, where it may develop to considerable size. In these same zones *Chordaria flagelliformis* may be found attached either to rocks or to larger plants. Although *Ectocarpus confervoides* and *E. siliculosus* in this habitat are primarily epiphytes on the fucoids, they are included in this community rather than as a component of the *Fucus* association. In other habitats, where a kelp association may be found, its members may be as densely populated as the fucoids with these same epiphytes.

Among the perennials is *Ralfsia fungiformis*, growing beneath the fuci on shaded sides of the intertidal rocks, and, where dilution is not too great, *Hildenbrandia* and *Lithothamnion* appear along with it. At submerged mouths of freshwater streams, *Rhodochorton purpureum* was found, albeit very infrequently, growing with the more tolerant annuals. It seems that *R. purpureum* from Labrador may be a highly adaptable species, tolerant of wide changes of salinity and other changes in environment. It is similar in this respect to the populations of *R. purpureum* seen in the Faeröes by Jónsson and by Børgesen (1905), and also similar to plants from Iceland reported by Rosenvinge (1900) and Jónsson (1912).

Although the number of species in this community is not large, by autumn the plants have formed a dense, luxuriant vegetation, at that time composed primarily of members of the Phaeophyceae. The following list includes the more significant species occurring in this assemblage. Those marked by an asterisk are most abundant.

<i>Ulothrix flacca</i>	<i>Eudesme virescens</i>
<i>Enteromorpha intestinalis</i>	* <i>Petalonia fascia</i>
<i>Monostroma fuscum</i>	<i>Dictyosiphon foeniculaceus</i>
<i>Prasiola crispa</i>	<i>Chorda tomentosa</i>
* <i>Pylaiella littoralis</i>	<i>Chorda filum</i>
<i>Ralfsia fungiformis</i>	* <i>Ascophyllum nodosum</i>
<i>Elachistea fucicola</i>	<i>Fucus distichus</i> subsp. <i>distichus</i>
<i>Chordaria flagelliformis</i>	* <i>Fucus distichus</i> subsp. <i>evanescens</i>

The *Fucus* association was seen in the innermost regions of many bays and fjords. Rock, wherever present in the intertidal zone, is conspicuously clothed with a dense growth of fucoids, and, where wave action is slight, even small pebbles may support the younger plants. Notable examples of stations having well-developed populations of fuci are Okak, Nutak, and Napartok bays, Hebron Fjord, and Nanook Pool. In somewhat more exposed areas the association is restricted to bed-rock.

In habitats of this nature Fuci are wanting in the upper shore. According to Jónsson (1912) the largest fuci occur in the "calm belt" immediately below the level of low tide on moderately exposed coasts. In Labrador, however, I have observed the most extensive populations and the broadest plants consistently growing near and below low-tide level in protected shallows. Such is the case in Nanook Pool where the mid-shore was covered by a colony of broad *Fucus vesiculosus*, at its lower limits growing with luxuriant plants of *F. distichus* subsp. *evanescens*, the latter spreading densely over the rocks of the low intertidal zone and extending into deep water.

The most abundant and widespread member of the *Fucus* association in this habitat is *F. vesiculosus*, which was found in all the quiet bays and fjords visited, where it constituted the largest portion of the vegetation of the littoral zone. With a slight increase in wave action and salinity, a second fucoid, *F. distichus*, may compete with *F. vesiculosus* in the lower intertidal zone. These two species can sometimes be confused in the field. Although not uncommon, particularly in the North, *Fucus vesiculosus* frequently lacks the slightest vestige of the paired bladders by which it is generally

easily recognized, and *F. distichus* subsp. *evanescens* may have peculiar terminal or subterminal bladders which may be paired or single. All questionable specimens collected were readily determined later with the aid of sections of the receptacles. The third member of the *Fucus* association, *Ascophyllum nodosum*, did not appear in the littoral zone of protected shallows on the eastern coast of Labrador, but frequently appeared just above the low-tide mark in similar regions on the western coast. As this species is considerably more prevalent in the sublittoral, however, its position in the *Fucus* association will be discussed later.

The *Calothrix* association forms a thin crust covering the mud and rock in the upper intertidal zone and when wet becomes iridescently black. The width of the *Calothrix* band depends upon the degree of exposure to surf and in protected areas may form a wide band which becomes reduced to a few scant centimetres with increased exposure.

The *Calothrix* crust primarily consists of the perennial blue-green alga *Calothrix scopulorum*. Frequent associates are *Gloeocystis scopulorum*, *Urococcus foslieanus*, *Codiolum pusillum*, *Ulothrix flacca*, and *Capsosiphon fulvescens*. It is interesting to note that the *Calothrix* association, including *Gloeocystis scopulorum* and *Urococcus foslieanus*, is found in the upper regions of all shores I have observed in the North, whether protected or exposed.

Sublittoral Algae. The bottoms of quiet bays are uniformly drab in appearance, commonly consisting of mud and sand with little rock, clothed with few species. Completely devoid of larger algae where large stationary rocks are absent, the bottom supports a community of summer annuals and small perennials.

In this habitat the communities of small perennials and summer annuals contain fewer species in the sublittoral than they do in the littoral, and some of these species are commonly in both zones. Such species as *Chordaria flagelliformis*, *Dictyosiphon foeniculaceus*, *Rhodomela confervoides*, and the seemingly ever-present *Pylaiella littoralis* appear by mid-July, forming distinctive clumps of delicately branching, loosely attached plants. Also found in the attached state was the little-understood alga *Chorda tomentosa*.¹ In the quiet shallow waters at the head of Hebron Bay, during October, 1955, it was collected in great quantity growing with the closely related species, *Chorda filum*. Associated with these algae were large populations of *Chordaria flagelliformis* and *Petalonia fascia*, both of which, with the two species of *Chorda*, literally covered all the smaller rocks at and just below the level of low tide. The continually submerged *Chordaria* plants were sparsely branched, if at all, consisting of long, loosely entangled, rope-like masses in contrast to the relatively small and much branched plants of the mid-littoral zone. Similarly, *Petalonia* appeared much longer than the typical intertidal forms commonly observed in these regions, closely approximating var. *zosterifolia* Taylor. Other annuals in this zone include *Monostroma fuscum*, *Ectocarpus confervoides*, *E. siliculosus*, and *Elachistea fucicola*.

¹The mouth of the Koksoak River and the inner harbour at Hebron, Labrador, were the only places where *Chorda tomentosa* was seen attached, but on numerous occasions along the western side of the Labrador peninsula it was found as drift.

The four small perennial species found on the intertidal rocks are found here in much greater abundance owing to the increased amount of shade in the sublittoral. At the bases of the fucoids, *Hildenbrandia prototypus* and *Lithothamnion* sp. thrive. As they are not largely restricted to this situation, growing equally well without fucoids, provided they are shaded by rocks or deep water, these species should not be considered as a part of the *Fucus* association.

Where larger rock is present, the *Fucus* association dominates the sublittoral community as it does the littoral, forming large masses of plants covering these rocks. On the western side of the Labrador peninsula, toward the heads of the long bays, attached *Ascophyllum nodosum* was generally found in the *Fucus* association, but more frequently in the sublittoral than in the littoral. On the eastern side of Labrador this species was seen attached only near the head of Okak Bay and in a very small colony near the head of Hebron Fjord, but it was collected many times as drift.

Both in the intertidal and submerged zones of the shore, the position occupied by *Ascophyllum nodosum* relative to that occupied by *Fucus vesiculosus* is variable. There is much confusion in the literature on this point, but according to Cotton (1912), Gislén (1930), Bell and MacFarlane (1933), and others, the positional relationship between the two species seems to be dependent upon the degree of exposure to wave action. These workers agree generally that in the North it is not uncommon for plants of both genera to be found continually submerged, a situation rarely encountered farther south. This is consistent with my own observations. According to E. Conway (1954), on the other hand, in the northern parts of the British Isles *A. nodosum* has an intermediate position between *Fucus spiralis* and *F. vesiculosus*. Here, as in the more northerly regions, *Ascophyllum* was the first element of the intertidal vegetation to be eliminated with increased exposure.

With the absence of *F. spiralis* in this region of the North, the vertical arrangement most commonly encountered is that of *Fucus vesiculosus* growing above the band of *Ascophyllum*. Frequently, where some shelter was afforded, *Fucus*, and sometimes *Ascophyllum*, extended well into the littoral. At the head of Okak Bay the upper limit of the *Fucus* population was more than a metre below low tide-level, forming a band approximately one-half metre wide. Merged with the lower limit of this *Fucus* belt, *Ascophyllum* extends below it, deep into the sublittoral. In this region of the bay the upper layers of water are greatly, if not completely, freshened. This, accompanied by destructive ice movements, is probably the main reason for this suppression of the entire association in the mid- and lower-littoral, where these species are best developed farther south.

As the bay becomes transitional between protected shallows and moderately exposed coasts, additional perennial species make their appearance, those belonging to the kelp association being the first encountered. This association is described in the discussion of the moderately exposed habitat.

The following list includes all the species observed in protected shallows. Some of these were not seen sufficiently often to warrant inclusion in the foregoing discussion. Plants that are most abundant are designated by an asterisk.

MYXOPHYCEAE

- | | |
|-------------------------------|--------------------|
| * <i>Calothrix scopulorum</i> | <i>Lyngbya</i> sp. |
|-------------------------------|--------------------|

CHLOROPHYCEAE

- | | |
|------------------------------------|------------------------------|
| <i>Gloeocystis scopulorum</i> | <i>Urococcus foslieanus</i> |
| <i>Codiolum pusillum</i> | <i>Monostroma fuscum</i> |
| <i>Ulothrix flacca</i> | <i>Percursaria percursa</i> |
| <i>Capsosiphon fulvescens</i> | <i>Prasiola crispa</i> |
| <i>Enteromorpha compressa</i> | <i>Rhizoclonium riparium</i> |
| * <i>Enteromorpha intestinalis</i> | <i>Spongomorpha lanosa</i> |
| <i>Enteromorpha micrococca</i> | |

PHAEOPHYCEAE

- | | |
|-----------------------------------|---|
| <i>Ectocarpus confervoides</i> | <i>Petalonia fascia</i> |
| <i>Ectocarpus siliculosus</i> | <i>Scytosiphon lomentaria</i> |
| * <i>Pylaiella littoralis</i> | <i>Dictyosiphon foeniculaceus</i> |
| <i>Ralfsia fungiformis</i> | <i>Chorda filum</i> |
| * <i>Elachistea fucicola</i> | * <i>Chorda tomentosa</i> |
| * <i>Chordaria flagelliformis</i> | <i>Ascophyllum nodosum</i> |
| <i>Eudesme virescens</i> | <i>Fucus distichus</i> subsp. <i>evanescens</i> |
| <i>Desmarestia aculeata</i> | * <i>Fucus vesiculosus</i> |

RHODOPHYCEAE

- | | |
|---------------------------------|-------------------------------|
| <i>Rhodochorton purpureum</i> | <i>Lithothamnion</i> sp. |
| <i>Hildenbrandia prototypus</i> | <i>Rhodomela confervoides</i> |

Periodicity

My knowledge of the algal communities of protected shallows is primarily based upon single trips to the heads of the long bays and fjords. As most of these visits were made during July and August, it was not possible for me to observe many early stages of the development of summer annuals in places of this kind. A late autumn (September to October) trip to Hebron in 1955 gave me the opportunity to see at one station the algal communities of this type of habitat at their peak of development.

During the first two weeks of July I visited the heads of Napartok, Nutak, and Okak bays and Kai-Kai Inlet, at which time the growth of annuals was limited to dense but restricted patches of *Ulothrix* and *Pylaiella*. The rock of the intertidal zone was not in the least slippery, indicating the absence of even a thin coating of diatoms. By the last week of July, rocks in similar habitats to the north were coated with filamentous diatoms and other small annuals which were extremely slippery. Below low tide-level the rocks

were chiefly covered with Fuci and, more rarely, *Hildenbrandia*, *Ralfsia*, small clumps of young *Dictyosiphon*, and *Pylaiella*. In the deeper water, however, *Pylaiella* was most commonly an epiphyte on the larger brown algae.

During the latter part of July similar habitats were visited in fjords (Saglek, Nachvak, and Kangalaksiorkvik) of northernmost Labrador. Here, attached to the rocks just below low tide-level, in the early stages of their development, were *Chordaria flagelliformis*, *Scytosiphon lomentaria*, *Dictyosiphon foeniculaceus*, and *Chorda filum*. During the late autumn of the following year, large well-developed populations of these plants were observed under similar conditions at the head of Hebron Bay. Other conspicuous annual additions to this community in Hebron Bay are *Petalonia fascia* var. *zosterifolia*, *Chorda tomentosa*, and *Rhodomela confervoides*.

The species of annuals common to the protected shallows are, for the most part, also found at more exposed stations. There is, however, a difference in the time of year that plants of the same species appear in each type of habitat; in many instances the development of algae in quiet bays precedes the development of the same species at exposed stations by more than two weeks. Accordingly, the initiation of the growth of annual species in the protected shallows most probably occurs during the first two weeks of July, reaching the peak of development around the first of October. *Ulothrix* and *Pylaiella* seem to appear even earlier, coming in soon after the first signs of the spring break-up.

MODERATELY EXPOSED COASTS

Regions of this kind, seen throughout the greater part of the area investigated, commonly support algal communities more luxuriant and diversified than those of any other habitat described in this study. Wherever there is even the slightest shelter between tide-marks, algae can be found, but the largest populations grow 10 to 30 metres below the level of low tide. Here I have seen the greatest number of species, some forming distinct associations characteristic of the deep-water vegetation of the north.

Where coastal rock is smooth or loosely consolidated, both the intertidal and upper sublittoral are sparsely vegetated (Plate III B). If, however, the coast is of uneven bed-rock, sizable plant communities develop in the protected crevices of the littoral and upper regions of the sublittoral.

Moderately exposed stations, although varying widely with the degree of exposure to surf and other physical features of the environment, all show similarities, making it possible to classify them as a distinct type, intermediate between protected shallows and exposed coasts. Specific examples of this habitat are the Hebron vicinity, the entrance to Saglek Bay, and the outer and middle reaches of Burwell Harbour.

Ecological Factors Operating Along Moderately Exposed Coasts

The character of moderately exposed coasts differs from that of protected shallows and wave-swept shores in several particulars, but in each instance these are differences of degree rather than of a qualitative nature.

Substrate. Much of the intertidal and upper sublittoral zones is admirably suited for the attachment of larger algae. One may generalize that as degree of exposure increases, amounts of silt, sand, and pebbles decrease. This correlation between substrate and exposure becomes apparent as one proceeds from the mouth toward the head of Hebron Fjord.

Salinity. Unless the head of an inlet terminates in a large river, the salinity of the water in the moderately exposed portion near the mouth remains relatively constant. There are noticeable salinity differences between the waters of the northernmost fjords, near Cape Chidley, and those with a lower salinity farther south on the Labrador coast. This was first pointed out by Tanner (1944), who says that these differences are manifest by "... a greater variety of phytoplankton with oceanic forms." This may partly explain also the greater diversity of attached marine plants in the littoral zone near the northern tip of the peninsula.

Movement of Ice and Water. All moderately exposed stations have, in common, shelter from the most severe surf; turbulence is natural, but full surging of the sea occurs only with the occasional storms. When situated close to the mouths of fjords or in the lee of an island, these coasts are continually subjected to the grinding movements of ice except during a few months of the year (Plate III A). Even in summer, after the ice has moved away from the coast and annual populations have become well established, a change in the direction of the wind can drive the ice rapidly shoreward again, bringing devastation to all unsheltered algae. Until this awesome spectacle has been witnessed, no concept can be formed of the magnitude of the ecological role played by moving ice. Such an event took place at Port Burwell shortly after I arrived in 1955. On July 21, ice in Burwell Harbour was restricted to infrequent floes toward the head of the harbour and in the lee of small promontories. A large ice-field moving eastward into the Gray Strait from Hudson Strait and Ungava Bay could be seen in the distance as a thin white line. During the night the wind shifted to the north, and by ten o'clock the following morning the ice-pack was nearing the shore. The dramatic effect of its approach was intensified by the threateningly calm sea which preceded the ice-field shoreward, the only sounds being the wind and crunching of ice-floes. At eleven o'clock the first floes bumped the shore, almost gently, but as more pressed in and piled up against it, their size and tremendous force was more fully appreciated. By mid-afternoon the entire harbour was filled with ice grinding at the coastal rocks. This ice did not leave Port Burwell until the first week in August. Its slow rise and fall with tidal changes heavily damaged the plants on the shore and in the shallow regions of the sublittoral. During a storm, the massive blocks were violently tossed against the coastal rock, destroying what remained of all but the most protected algal communities. It is little wonder that Kjellman (1877, 1883) considered the presence of arctic ice to be the primary deterrent to the formation of large populations of northern marine algae.

Vegetation

My discussion of the algae in the littoral zone of moderately exposed coasts, based on collections and observations made throughout the area, is a composite description of the shore vegetation of the Labrador peninsula, with specific differences indicated for local areas. My knowledge of the flora of deeper water is more limited. In this case, discussion is based upon the results of deep-water dredging with a beam trawl at a few stations and, equally important, upon a study of great quantities of drifting plants.

Littoral Algae. Although algal communities in the littoral zone of arctic regions are at best restricted, they flourish along the moderately exposed coasts. Plant communities in habitats of this kind vary greatly in size according to the degree of exposure, the slope, and the uniformity of the shore. I recognize a number of vegetational bands dividing the shore horizontally according to the positions always occupied by certain plants.

The lowest limit of terrestrial vegetation is a dark, sharply defined band of crustose lichens, most commonly *Haematoma ventosum* (L.) Mass. and *Umbilicaria* sp. Immediately below the lichen band is a barren region unsuitable for colonization by either algae or land plants. This level of the shore varies in width from one-half to one metre and is conspicuous by virtue of its usually lighter colour than the bordering bands above and below.

Below the barren zone is an almost continuous band of *Prasiola crispa*, intense green at the height of its development. In places this 'green' band is well above the level of high spring tides, frequently subjected to long periods of desiccation, wetted only by spray from breaking waves and periodically by fresh water. *Prasiola* is generally found on all but the most exposed rock surfaces at the uppermost level of this type of shore. Where there is shelter from the surf, the *Prasiola* band may be sharply defined, a metre or more wide, and easily seen either from shore or from a vessel. Børgesen (1905) reported *Prasiola crispa* from the Faerøes as occupying a similar position on the shore. Both Cotton (1912) and Jónsson (1912), however, in describing the shore vegetation of Clare Island and Iceland, state that there *P. stipitata* is the uppermost alga, forming large colonies similar to those described by Børgesen and to the ones I have seen in Labrador. Cotton and Jónsson both refer to some occurrence of *P. crispa* with *P. stipitata*, but the latter remains dominant. Both species seem to grow in strongly nitrogenous places. Such conditions prevail near the Eskimo villages of Nutak and Hebron where, in addition to the usual amounts of organic debris that is common near native villages, further quantities of waste nitrogenous materials result from the operations of sizable fish stages, locally known as 'fish factories.' Here, as might be expected, colonies of *P. crispa*, *U. flacca*, *M. fuscum*, and *S. arcta* were exceptionally well developed. In still other areas it is possible that *P. crispa*, like *P. stipitata*, colonizes the upper limits of the shore because of the greater concentration of nitrogenous compounds, chiefly bird droppings, found at that level.

Mixed with the *Prasiola* community, but usually to a small extent when present, are *Urococcus* and *Gloeocystis*, also *Calothrix*, *Rivularia*, and other *Myxophyceae*. More commonly these algae form, immediately below the 'green' belt, a distinct band which may measure two metres in

depth, the dull orange of mature *Urococcus foslieanus* situated directly above the *Calothrix scopulorum*. Like the *Prasiola* band, the 'orange-black' band is horizontally continuous, frequently for considerable distances. In the upper littoral, *Enteromorpha micrococca* generally forms a discontinuous band immediately below the 'orange-black' band. At moderately exposed stations this species is typically found on the shaded sides of rocks and in crevices where there is a continual drip of fresh or salt water. Under favourable conditions the filaments are a deep green, branching abundantly, and are commonly long and slightly twisted, the cells having relatively thick walls. During the early part of the summer in this region of the shore, *Ulothrix flacca* may become a significant element of the vegetation. This species is most abundant where there is constant seepage of land runoff.

One of the highest attached algae, *Rhodochorton purpureum*, is apparently not restricted to any particular region of the intertidal zone, at times extending well below the level of low tide. *Rhodochorton*, seemingly intolerant of strong light and desiccation, is found in shaded crevices when growing high on the shore. Lower on the shore, where drying is not so severe, this alga apparently becomes more tolerant of light and may be found on rock surfaces exposed to direct sunlight for short intervals each day. In shade this plant is deeply pigmented, becoming less so, as light intensity increases. On the leeward side of a rock in the low littoral it may form distinct subglobose tufts, but more commonly it forms a characteristic low-growing turf.

Before discussing the Fuci of the northern coasts, I would like to point out that *Fucus* is taxonomically a very difficult genus. There is considerable confusion in the literature dealing with its various species and forms, and investigators may differ widely in their interpretations. During the present studies I have seen plants that agree in every respect with all the species of *Fucus* previously recorded for Atlantic North America with the exception of *F. serratus* and *F. spiralis*. Species of *Fucus* found in the Canadian Northeast are readily separated into two distinct and naturally occurring groups, the monœcious (hermaphroditic) and the diœcious forms. Of the former, *Fucus vesiculosus* stands apart from the remaining plants. The question of naming the members of the diœcious group, on the other hand, presents a more difficult problem. The widely different forms of this group¹ have been described as forms and species by various authors. Until recently these plants were generally accepted by European phycologists as forms of the one species² (Rosenvinge, 1894; Jónsson, 1912; Evans, 1947; Powell, 1954). On the other hand, these plants retain species rank supported by the studies of American authors (Bell and MacFarlane, 1933; Johnson and Skuteh, 1928; Taylor, 1957; and T. A. and A. Stephenson, 1954). In further studies of the diœcious species of *Fucus*, Powell (1957) regards the name *F. inflatus* L. to be based on specimens (two incomplete plants) "that are most probably plants of *F. vesiculosus* L." and therefore invalid in its current use. He re-establishes *F. distichus* L. as the earliest acceptable name for the group of plants in question and includes all the other taxa previously described in this assemblage under four subspecies:

¹Hereafter to be called the 'distichus' group, Powell (1957).

²Previously referred to by Europeans as *Fucus inflatus*, currently *Fucus distichus* L. emend. Powell.

subsp. *distichus*; subsp. *anceps* (Harv. et Ward ex Carruthers) Powell, n. comb.; subsp. *edentatus* (De la Pyl.) Powell, n. comb.; and subsp. *evanescens* (C. Ag.) Powell, n. comb. In the following discussions of these dioecious forms of *Fucus* the names given by Powell will be used. I have made mass collections of this particular group at numerous stations throughout the entire region. Field and laboratory studies of these plants reveal intermediate types (forms) from large, robust plants to small, delicately branched, filiform fuci, which tend essentially to substantiate the views of Powell in his recent interpretation of this group.

The *Fucus* growing highest on the shore, *F. distichus* subsp. *distichus*, is most commonly found in tide pools of the upper littoral zone. In this habitat it reaches a peak of development and expresses a wide range of habit. In most instances the smaller, more delicately branched plants are found in the highest most insolated pools. With less exposure to sunlight and shorter periods of tide-pool emergence, the plant form becomes intermediate between the narrow varieties of *F. distichus* subsp. *evanescens* and the common forms of tide pool subsp. *distichus*. It is not uncommon that both of the subspecies are found growing together in the same tide pool, although I am unable to attribute this fact to specific ecological conditions.

As early as 1829 De la Pylaie indicated that subsp. *distichus* is not entirely restricted to the tide-pool habitat, being found on occasion elsewhere attached to the rocks of the upper intertidal zone. In Labrador and northern Quebec I have found this ecological form of subsp. *distichus* as widely separated patches or small clumps in the cracks and sheltered depressions of overhanging rock, and always in lesser abundance than the tide-pool form of the subspecies. Such plants differ only slightly from the latter. Generally they are more delicate, with lengthy, compressed receptacles in contrast to the uniformly terete receptacles of the tide-pool plants and, as in the case of subsp. *anceps*, only a few cryptostomata are to be found in the upper branch segments. Though certainly a significant component of the intertidal vegetation of more sheltered regions, this form of subsp. *distichus* is never present on the rocks of the exposed habitat. Although *F. distichus* subsp. *distichus* is found in two distinct and ecologically widely different habitats, the morphology of the plants is so slightly variable that the naming of different forms would be unnecessary. The emergent form of subsp. *distichus* was most abundant in southern Labrador, but it was also found in the outer regions of some bays and fjords to the north.

The most conspicuous *Fucus* attached in the mid-littoral of moderately exposed coasts is *F. vesiculosus*, also forming dense populations throughout much of the lower shore, except where there is inadequate shelter from the waves. All along these moderately exposed parts of the coast it is free from competition from *Ascophyllum nodosum*. However, only scattered plants, which are continuously submerged, are found here, whereas in protected shallows, *F. vesiculosus* formed large colonies both above and below low tide-level. Because of an abundance of ice in these moderately exposed regions during much of the year, *Fucus* is restricted to cracks and depressions in the mid-littoral rock and the sheltered faces of boulders. Late in the autumn, *Fucus* sporelings may be found in less protected spots, but these

plants are short-lived, torn from the rocks soon after the ice is formed. I have seen remnants of these plants still attached to the rocks after the spring break-up. In most instances only the holdfast and a portion of the stipe remain, but even these small fragments possess powers of regeneration. Late in the summer there is usually ample evidence of this vegetative proliferation, which, as a rule, results in mis-shapen plants ultimately very bushy toward the base.

More important than *F. vesiculosus* as an intertidal rock cover in this habitat is *F. distichus* subsp. *evanescens*. Occurring commonly at and below the lower limits of *F. vesiculosus*, it may completely dominate the aspect of the lower shore, its form varying directly with the degree of exposure to surf. Jónsson's (1912) description of the *F. distichus* subsp. *evanescens* community¹ in Iceland is quite applicable throughout much of the Labrador region. In accordance with the degree of exposure to wave action, he divides this community into three belts, namely, the "surf-belt," the "wave-belt," and the "calm-belt." The latter, belonging to the sublittoral, will be discussed with that zone rather than here. He considers the upper portion of the *F. distichus* subsp. *evanescens* population on fully exposed rocky coasts to be the "surf-belt." According to Jónsson, the fuci of this belt are, as a rule, small, leathery, and much branched; from 5 to 9 centimetres high for his dwarf form "exposita," to much taller in the case of form "dendroides." At many stations exposed to the surf, I have found plants very similar to those described by Jónsson growing abundantly on projecting rocks. Where the exposure is greatest, however, many fruiting plants were only one centimetre long, becoming larger with less severe exposure. The branching of these forms of *F. distichus* subsp. *evanescens* is flabellate; the receptacles are small, pointed, and mostly compressed; and the segments of the plants generally are extremely dark when dry and possess few cryptostomata. At the more northern stations and all of the most exposed localities I have visited, this form of subsp. *evanescens* was the dominant and the habit most typical of these environments. In most instances it is readily distinguishable from the larger, lighter coloured plants of this subspecies, characteristic of less exposed regions and in more southerly areas. Hereafter I will refer to this form of subsp. *evanescens* as its 'northern' form. I have found these plants in fruit through June, July, and August.

Jónsson's "wave-belt" includes "... the ordinary *Fucus inflatus* (*F. distichus* subsp. *evanescens*) belt" of the intertidal zone. I presume from his description that this belt is situated just above the "surf-belt" and is less directly exposed to surf. The description he gives of this *Fucus* belt agrees with my own findings. In this region of the shore *F. distichus* subsp. *evanescens* is commonly 30 centimetres long, and where most sheltered it may be up to 60 centimetres in length. Because of their greater size, the generally swollen appearance of their receptacles, the increased number of cryptostomata, and the usual lighter colour of the thallus, the fuci of the "wave-belt" and quiet areas of moderately exposed coasts differ sharply from the foregoing or the 'northern' form of subsp. *evanescens*. These plants become progressively more abundant in regions to the south in both exposed and sheltered environments. In general, the largest populations of this subspecies are found wherever the shore consists of

¹Jónsson refers to this as the *F. inflatus* association.

talus boulders. Although I refer to dense populations of fuci occurring from about mid-shore to, and below the level of, low tide, I must emphasize that they are never attached to the exposed surfaces of rocks in this region; thus, at most, the *Fucus* colonies form scattered patches over the shore.

Fuci agreeing well with *F. distichus* subsp. *edentatus* were collected in a few widely separated localities along the Labrador coast and in northern Newfoundland. In each instance the plants were attached at or just below the level of low tide along moderately exposed coasts. At the more northern stations I have never seen this plant in abundance, whereas in boreal regions it is a conspicuous component of the low intertidal flora. I have collected representative plants and have observed large populations of this subspecies from Cape Cod, Massachusetts, northward to the south coast of the Labrador peninsula, where it is abundant but less so than subsp. *evanescens*. The centre of distribution for subsp. *edentatus* on the northeast coast of North America is apparently at the latitude of the eastern Canadian Maritime Provinces with a northward extension quite evident to the north shore of the Strait of Belle Isle. At its centre of distribution and to the south as far as New Jersey (Taylor, 1957), the plants are moderately large, 2 to 4 dm. in height, but have been reported up to 9 dm. Northward from the upper regions of the island of Newfoundland these plants become progressively reduced, showing none of the robust characteristics of the 'southern' plants. In all instances, however, subsp. *edentatus* is characterized by elongate receptacles that are markedly compressed, a paucity of cryptostomata, and an invariably dark brown to black overall appearance.

The exposed low and mid-littoral areas between the *Fucus* colonies support few species, but in late August and through the autumn months these are represented in large numbers. *Pylaiella* and *Spongomorpha* are important throughout the littoral zone and extend into the sublittoral, but in terms of the surface area covered by annual species, the associations of *Chordaria*, *Petalonia*, and *Scytosiphon* are the most significant. These plants completely dominate the appearance of the lower shore, forming a "brown" band during late summer and autumn. An extremely polymorphic species, *Chordaria flagelliformis*, is represented here by many forms, whereas *Petalonia* and *Scytosiphon*, although responsive to major ecological changes, do not seem to vary greatly within the radius of a single station.

In the areas I visited, and presumably throughout the Canadian Northeast, there were only a few local regions of the coast where great quantities of waste nitrogenous materials are discharged into the sea. One such station was the vicinity of a fish-processing wharf at the Eskimo village of Hebron. Presumably as a result of this pollution, the region of the shore near the wharf supports rich populations of Chlorophyceae during the latter part of the summer and autumn. Especially prevalent in this group were *Enteromorpha intestinalis*, *Monostroma fuscum*, and *Spongomorpha arcta*. During autumn an equally luxuriant vegetation of phaeophycean annuals was evident.

Sublittoral algae. When Jónsson described his "calm-belt," he restricted it to the area immediately below the low tide-level. I will include the entire sublittoral in my discussion of this belt rather than follow his limited usage of this term. In the calm belt, *Fucus distichus* subsp. *evanescens* is frequently long, with a greater frond-width than the plants of the other two belts, which are often sterile and tend to be very dark. Generally these plants are not abundant and lie loose on the bottom or attached to rock at depths of 6 to 15 metres. In protected shallows, as might be expected, considering the relative quietness of the water, the fuci of the lower littoral are comparable in form to those of the calm belt of moderately exposed coasts.

At and below the level of low spring tides, usually at the lower limits of the 'brown' band, one finds enormous populations of *Halosaccion rametaceum*, *Rhodymenia palmata*, and, at times, *Monostroma fuscum*. Three especially common epiphytes of the two rhodophycean species, although by no means restricted to these host plants, are *Elachistea fucicola*, *Pylaiella littoralis*, and *Spongomorpha arcta*. *Elachistea* can invariably be found with *Halosaccion* and *Fucus*, but the epiphytes of *Rhodymenia* are somewhat less constant. The close proximity of large numbers of *Rhodymenia* and *Halosaccion* to the phaeophycean 'brown' band immediately above, results in a striking pattern of colours. With these two reds, but not forming large local populations, are the various species listed below, most of which may be expected in the deeper tide pools as well as in this habitat.

<i>Enteromorpha compressa</i>	<i>Monostroma fuscum</i>
<i>Monostroma oxyspermum</i>	<i>Dilsea integra</i>
<i>Ulva lactuca</i> var. <i>rigida</i>	<i>Polyides caprinus</i>
<i>Chaetomorpha melagonium</i>	<i>Euthora cristata</i>
<i>Spongomorpha lanosa</i>	<i>Rhodophyllis dichotoma</i>
<i>Spongomorpha arcta</i>	<i>Ahnfeltia plicata</i>
<i>Chaetopteris plumosa</i>	<i>Antithamnion boreale</i>
<i>Sphacelaria arctica</i>	<i>Ptilota serrata</i>
<i>Lithoderma extensum</i>	<i>Membranoptera denticulata</i>
<i>Elachistea fucicola</i>	<i>Phycodrys rubens</i>
<i>Desmarestia aculeata</i>	<i>Odonthalia dentata</i>
<i>Isthmoplea sphaerospora</i>	<i>Polysiphonia arctica</i>
<i>Stictyosiphon tortilis</i>	<i>Rhodomela confervoides</i>
<i>Delamarea attenuata</i>	

Certain of the above genera, such as *Isthmoplea*, *Ulva*, and *Delamarea*, were found rarely, and at widely separated stations. *Isthmoplea*, the only plant in this group seen unattached, was collected entangled with larger algae and as drift near the mouth of False River Bay and at Port Burwell. *Ulva* was seen at a single station near Port Burwell, and *Delamarea* was collected at Hebron and Saglek. Still another plant of somewhat restricted distribution is *Polyides caprinus*. At Hebron during July and August, 1954, I observed *Polyides* both as drift in great quantity, and in less abundance as attached plants immediately below low tide and in tide pools. At the same station in late August and September of 1955 it was collected only as drift. In the vicinity of Port Burwell, the only other station

where this species was seen in any quantity, it was seen only in drift during the entire summer of 1955. The occurrence of *Stictyosiphon tortilis* and *Rhodophyllis dichotoma* was just the reverse, being found attached through much of the year at Port Burwell and only infrequently attached at Hebron where it appeared in large amounts in drift.

Where the bottom consists of rock in the deeper areas, below 3 to 5 metres depth, it is characterized by the kelp association and extensive patches of the crustose species of Lithothamnion. As I have mentioned in the discussion of tide pools, smaller plants of the Laminariaceae may be found from the low littoral, where they must be continually at least partially submerged, to considerable depths in the offshore waters. Kelp communities along moderately exposed coasts vary considerably with regard to the kind and number of species they contain. Moreover, individuals of the same species, in response to environment, manifest great variability in shape. Differences in the species constituting the kelp community, as well as the morphological differences of some individuals, may be primarily attributed to water and ice movements and to the position of attachment to the bottom with reference to the level of low tide.

I have observed members of the Laminariaceae in two distinct minor habitats differentiated on the basis of exposure to surf and the position of the station on the shore. These are, (1) relatively quiet sublittoral areas of moderately exposed coasts, and (2) deeper, more turbulent regions, closely approximating the sublittoral conditions of a wave-swept coast. In the following discussion these minor habitats will be described in terms of the kelp associations characteristic of each.

1. *Relatively quiet sublittoral areas of moderately exposed coasts:*

In these regions I found immense kelp in large and, more often than not, discrete beds. Kelp beds of this nature are frequent in this type of northern habitat, forming veritable 'forests' of vegetation, the bulk of which consists of *Laminaria longicruris*. This dominant species, generally dwarfing all the other members of the community, is usually 10 to 12 metres long, but not uncommonly attaining a length of 15 metres; on more than one occasion I measured the blade to be $1\frac{1}{3}$ metres wide. At low tide the crozier-like region at the junction of the stipe and blade of *L. longicruris* commonly appears 10 to 15 centimetres above the water surface.

Other quiet sublittoral regions may be characterized by entirely different associations. By dredging with a beam trawl I found areas of this type to contain almost pure stands of *Agarum cribrosum* in one instance (Okak Bay, Plate X A) and *Saccorhiza* in another (Nutak Bay). On both occasions the dominant species of the under vegetation was *Phyllophora interrupta* and *Kallymenia schmitzii* (Plate X A and B).

In the *Laminaria longicruris* association, growing beneath the dominant species is a large assemblage of species which roughly forms two stories or layers of vegetation. The upper story consists largely of other kelps of varying sizes, but usually smaller than the dominant species of the

association. In this community the kelps are represented by a greater number of species than are found in any other environment. The members of the Laminariaceae tentatively associated here are listed below.

<i>Agarum cribrosum</i>	<i>Laminaria saccharina</i>
<i>Alaria grandifolia</i>	<i>Laminaria solidungula</i>
<i>Laminaria groenlandica</i>	<i>Laminaria nigripes</i>
<i>Laminaria longicruris</i>	<i>Saccorhiza dermatodea</i>

The lower story or 'under vegetation' contains primarily small algae, mostly epiphytes attached to the bases of the larger plants. The algae common to this lower story of the 'longicruris' community have all been seen under other conditions in the sublittoral and lower shore, but it is here that they reach their best development. The species below are the principal constituents of the 'under vegetation' in these circumstances.

<i>Monostroma fuscum</i>	<i>Rhodochorton penicilliforme</i>
<i>Chaetomorpha melagonium</i>	<i>Dilsea integra</i>
<i>Spongomorpha arcta</i>	<i>Lithothamnion</i> sp.
<i>Pylaiella littoralis</i>	<i>Euthora cristata</i>
<i>Chaetopteris plumosa</i>	<i>Kallymenia schmitzii</i>
<i>Lithoderma extensum</i>	<i>Rhodophyllis dichotoma</i>
<i>Desmarestia aculeata</i>	<i>Ahnfeltia plicata</i>
<i>Litosiphon filiformis</i>	<i>Phyllophora interrupta</i>
<i>Rhodymenia palmata</i>	<i>Pantoneura baerii</i>
<i>Antithamnion boreale</i>	<i>Phycodrys rubens</i>
<i>Ptilota serrata</i>	<i>Odonthalia dentata</i>
<i>Membranoptera alata</i>	<i>Polysiphonia arctica</i>
<i>Membranoptera denticulata</i>	

2. Deeper, more turbulent regions:

Examples of this type of habitat are prevalent, occurring at and near all coastal promontories. Here currents and waves, little deflected from their shoreward movement, are noticeably more severe in their action than in other regions of the moderately exposed coast. Because of this exposure, vegetation is restricted to considerable depths, beginning at approximately 9 metres.

The members of the kelp association here are commonly long, narrow, and robust plants; holdfasts and stipes are exceptionally well developed, and in species for which dissection is normal, the blades are usually divided many times. In this association the following species should be included: *Laminaria solidungula*, *L. nigripes*, and *Alaria grandifolia*. Primarily a deep-water species, *L. solidungula* was very rarely seen in the shallow (10 to 20 metres depth) inshore water. However, *L. nigripes* and *A. grandifolia* grow in great abundance wherever sheltered niches or the depth of the water afford protection. Due to the inaccessibility of these communities, I am unable to discuss their less conspicuous members, but as I have previously stated, the 'under vegetation' on rock substrate in this type of situation is much reduced.

Epiphytes of the kelps are for the most part found only on *Laminaria*, occurring on the stipes and blades of these plants in both of the minor habitat communities. These epiphytes are listed in order of their importance as follows: *Pylaiella littoralis*, *Rhodymenia palmata*, *Membranoptera denticulata*, *Rhodophyllis dichotoma* (Plate XI A), *Euthora cristata*, and less commonly, *Giffordia ovatus*, *Ptilota serrata*, *Spongomorpha arcta*, *Monostroma fuscum*, and *Litosiphon filiformis*. Near Port Harvey, Quebec, I observed the three last species attached in great quantity to the stipe of *L. longicruris*. With maturity the stipes and blades of *Laminaria* become roughened by natural proliferations forming small wart-like protuberences or by crustose invertebrate colonies. Regardless of the method of roughening, these areas serve admirably for spore attachment and support of germlings. These parts of the plant invariably become densely clothed with great numbers of such small plants as *Pylaiella littoralis*, *Giffordia ovatus*, *Litosiphon filiformis*, and *Spongomorpha arcta*.

During the latter part of August at Port Burwell and through September and October at Saglek and Hebron, the drift plants from the sublittoral consisted almost entirely of masses of *Ptilota serrata* and *Rhodymenia palmata*, indicating the general aspect of the deep-water 'under vegetation' during much of the summer months. With the exception of *Halosaccion*, which is primarily found in the high sublittoral and lower littoral, no other member of the Rhodophyceae of comparable size surpasses these two species in number of individuals in any given area.

The following tabulation includes all the species collected at moderately exposed coastal stations. Those species marked with one asterisk were not seen in the attached state; those marked with two asterisks were most prevalent.

MYXOPHYCEAE

<i>Entophysalis conferta</i>	<i>Lyngbya</i> sp.
** <i>Calothrix scopulorum</i>	<i>Scytonema</i> sp.

CHLOROPHYCEAE

<i>Glococystis scopulorum</i>	<i>Ulva lactuca</i> var. <i>rigida</i>
<i>Urococcus foslieanus</i>	** <i>Prasiola crispa</i>
<i>Codiolum pusillum</i>	<i>Chaetomorpha linum</i>
** <i>Ulothrix flacca</i>	<i>Chaetomorpha melagonium</i>
<i>Capsosiphon fulvescens</i>	<i>Cladophora glaucescens</i>
<i>Enteromorpha compressa</i>	<i>Rhizoclonium riparium</i>
<i>Enteromorpha intestinalis</i>	<i>Spongomorpha arcta</i>
<i>Enteromorpha micrococca</i>	<i>Spongomorpha lanosa</i>
** <i>Monostroma fuscum</i>	<i>Urospora penicilliformis</i>
<i>Monostroma oxyspermum</i>	

PHAEOPHYCEAE

<i>Ectocarpus confervoides</i>	<i>Ralfsia verrucosa</i>
<i>Ectocarpus siliculosus</i>	<i>Lithoderma extensum</i>
<i>Giffordia ovata</i>	<i>Elachistea fucicola</i>
** <i>Pylaiella littoralis</i>	** <i>Chordaria flagelliformis</i>
<i>Chaetopteris plumosa</i>	<i>Eudesme virescens</i>
<i>Sphacelaria arctica</i>	<i>Alaria grandifolia</i>
** <i>Desmarestia aculeata</i>	<i>Laminaria groenlandica</i>
* <i>Desmarestia virescens</i>	** <i>Laminaria longicruris</i>
* <i>Isthmoplea sphaerospora</i>	** <i>Laminaria nigripes</i>
<i>Stictyosiphon tortilis</i>	** <i>Laminaria saccharina</i>
<i>Delamarea attenuata</i>	<i>Laminaria solidungula</i>
<i>Litosiphon filiformis</i>	<i>Saccorhiza dermatodea</i>
** <i>Petalonia fascia</i>	** <i>Fucus distichus</i> subsp. <i>evanescens</i>
<i>Scytosiphon lomentaria</i>	<i>Fucus distichus</i> subsp. <i>distichus</i>
<i>Dictyosiphon foeniculaceus</i>	<i>Fucus distichus</i> subsp. <i>edentatus</i>
<i>Agarum cribrosum</i>	<i>Fucus vesiculosus</i>
<i>Ralfsia fungiformis</i>	

RHODOPHYCEAE

<i>Bangia fuscopurpurea</i>	** <i>Rhodymenia palmata</i>
<i>Porphyra miniata</i>	<i>Antithamnion boreale</i>
<i>Rhodochorton penicilliforme</i>	<i>Ceramium rubrum</i>
<i>Rhodochorton purpureum</i>	<i>Ceramium</i> sp.
<i>Dilsea integra</i>	<i>Ptilota plumosa</i>
<i>Polyides caprinus</i>	** <i>Ptilota serrata</i>
<i>Hildenbrandia prototypus</i>	<i>Membranoptera alata</i>
<i>Lithothamnion</i> sp.	<i>Membranoptera denticulata</i>
<i>Euthora cristata</i>	<i>Pantoneura baerii</i>
<i>Kallymenia schmitzii</i>	<i>Phycodrys rubens</i>
<i>Rhodophyllis dichotoma</i>	<i>Odonthalia dentata</i>
<i>Ahnfeltia plicata</i>	<i>Polysiphonia arctica</i>
* <i>Phyllophora brodiaei</i>	<i>Polysiphonia urceolata</i>
* <i>Phyllospora interrupta</i>	** <i>Rhodomela confervoides</i>
** <i>Halosaccion ramentaceum</i>	<i>Rhodomela lycopodioides</i> f. <i>flagellaris</i>

Periodicity

Even though for much of the year the area between tide-marks is dominated by perennial species, it is the smaller algae, present for relatively short periods of time, that so drastically change the appearance of the shore. These seasonal fluctuations of the vegetation are most marked along the moderately exposed coast. In view of the similarity of the environments of this kind on the east and west sides of the peninsula, I will treat them together. In moderately exposed regions, algal periodicity follows a sequence much like that occurring in protected shallows.

During the last week of June, 1954, and the first two weeks of July, 1955, I observed many stations of this type, all of which at this time were generally barren of seasonal species in the littoral zone. Only a few species, usually *Prasiola crispa*, *Enteromorpha micrococca*, *Ulothrix flacca*, and *Pylaiella littoralis*, constitute the early spring flora. As in protected shallows, *Prasiola* was the first to make an appearance, forming the characteristic 'green' band high in the littoral. It was soon followed by *Enteromorpha* and *Ulothrix*, appearing below the perennial *Calothrix* band, and *Pylaiella*, which at this time could be found in the low littoral and in tide pools.

In the low littoral during the first part of July, I observed the early development of large populations of *Spongomorpha*, *Halosaccion*, and probably *Urospora*. Where the most protection was afforded, *Rhodymenia* could be found growing below *Halosaccion*. It is interesting that in some regions, *Halosaccion* and *Rhodymenia* had attained a size suggesting that these plants began their development in mid-June. I am unable to say whether the early development of these species begins before the actual spring break-up or shortly after. I am inclined to believe, however, that little growth occurs while the ice remains solid on the shore.

Even in the most protected spots of the moderately exposed habitats, the areas below the *Enteromorpha* and *Ulothrix* of the high littoral, down to the more exposed mid-littoral, remain barren for much of the summer season, except for the scattered *Fucus* colonies. Toward late July these barren areas become seeded with *Pylaiella*, which becomes an almost continuous covering, with *Spongomorpha* forming less extensive patches. Where the latter is found near continual seepage of fresh or marine runoff, the plants usually become larger and the colonies more extensively developed. Late in autumn the rocks of this level of the shore remain densely clothed with these plants and additional members of the *Phaeophyceae*. During the spring and much of the summer, the shore from the high sublittoral to the 'spray zone' is characterized by the following annuals:

<i>Ulothrix flacca</i>	<i>Pylaiella littoralis</i>
<i>Enteromorpha micrococca</i>	<i>Halosaccion ramentaceum</i>
<i>Prasiola crispa</i>	<i>Rhodymenia palmata</i>
<i>Urospora penicilliformis</i> (?)	

The most striking aspect of the algal periodicity I observed on a moderately exposed shore was the seeding-in and subsequent development of *Chordaria flagelliformis* near Port Burwell during the latter part of the summer, 1955. *Chordaria* sporelings were first seen on July 28, at which time the plants were less than 0.5 centimetre high, arising from what seemed to be an oversized basal disk, the individual colony appearing as a small pin-cushion with numerous light buff hairs emerging from it. These sporelings, extremely abundant throughout the lower shore and upper sublittoral, were attached to rocks, molluscs, or to other plants, and were equally common on the calcareous debris usually found on the bottom of tide pools. By the last week of August, this alga completely dominated the appearance of the shore where uninhabited by large perennials. At that time the plants were 8 to 10 centimetres long with many short lateral

branches, corresponding to Farlow's variety *densa*. In protected shallows, *Chordaria* was noticeably larger than the plants here, remaining so for the entire growing season, perhaps as a consequence of the more sheltered conditions or as a result of an earlier start and longer growth period.

Growing with *Chordaria*, though in much less extensive populations, were *Petalonia fascia* and *Scytosiphon lomentaria*, both with a life span probably similar to that of *Chordaria*.

FULLY EXPOSED COASTS

Much of the outer coastline of the Labrador peninsula is typically wave-swept through the summer and autumn seasons and subjected to the ravages of moving ice for the remainder of the year. As defined by O. Sundene (1953), the exposed coast is "... a locality where there is free horizon over an extended area and no protection against the swell." The environmental factors operating along this kind of coast restrict algal vegetation to the most protected niches of the intertidal rock and to the offshore waters. Where the exposed coastal areas consist of disarranged rock of all sizes and forms, the vegetation may consist of an appreciable number of species. If, however, as is more often the case, the shore consists of long stretches of comparatively unbroken bed-rock, which has been smoothed by moving ice and water, algae are mostly wanting (Plate VI A). Since degree of exposure varies from station to station and also within a given station, it is possible to find in some of the restricted crevices communities that, except for their small size, are typical of those found along moderately exposed coasts. In general, however, the factor of exposure operates to such an extent that these environments are distinct from all others described in this paper.

Specific examples of this habitat are as follows: Watchman Island (Station No. 16), Cape Morhardt (Station No. 17), Cape Uivuk (Station No. 18), and numerous stations along the east coast of Ungava Bay (No. 32).

Ecological Factors Along Fully Exposed Coasts

Whereas moderately exposed coasts support large populations of attached marine algae, conditions here prohibit extensive plant growth. I will merely make reference to the description of moderately exposed regions when necessary, inasmuch as the ecological factors mentioned there operate in the same way, but to a greater degree, on fully exposed coasts.

Substrate. The shore consists of either bold cliffs with a boulder talus at the base or of gently sloping relatively unbroken shelf rock. In each instance, the typical granites and gneisses have been well worn by the continual abrasion of ice and the small rocks moving about in the surf and currents (Plate III B; Plate VII A). Consequently the usually numerous small crevices in which algal spores are lodged by water movements are less frequently seen here.

Salinity. The waters of the exposed coast are little modified by those of the open sea through much of the year. Small seasonal fluctuations of temperature and salinity occur, corresponding with the degree of insolation and the peaks of surface runoff from melting snow and ice on land.

Movement of Ice and Water. Exposed habitats differ from more sheltered coasts in that here the movements of the ice-floes and water are far more violent. It is interesting to note that floe ice may be present as late as mid-August along the Labrador coast, even to the point of blocking all shipping.

The water mass moving around the southern tip of Greenland (Cape Farewell) meets the Baffin Island Current in the vicinity of the Davis Strait Ridge and is soon joined by water flowing from the west through Hudson and Gray straits. This merging results in the formation of the southward moving Labrador Current. Each of the water masses contributing to this current brings with it varying amounts of floe ice. This ice ultimately drifts south to the Labrador coast or even to the east coast of Newfoundland.

On even the most exposed coasts, an ice-foot or "sina" is formed through the winter and spring, covering the upper shore often as late as the end of July. In the region of the shore below this ice-foot, immense pieces of floe ice are continually being cast about by the waves and currents.

Vegetation

In a discussion of the configuration of the coast with respect to marine algal growth, Kjellman (1883) states, "... I have never, within the confines of the arctic sea, found any noteworthy littoral vegetation on an exposed coast, but only in sheltered places on the inside of the isles." This is to be expected, in view of what has been discussed for the other habitats in relation to the effects of ice, surf, and waves.

Littoral Algae. Marine plants of an exposed intertidal area only occur where the shore is greatly broken up by sheltered areas. Banding of the vegetation is hardly evident, except for the *Prasiola* (green) and *Calothrix* (black) belts, but much later in the summer a belt of brown filamentous species becomes apparent low on the shore. Spray from the surf raises the level of these first two belts, at times high above the spring high tides. Other low-growing annuals associated with these bands and mentioned previously are of frequent occurrence. As seen on the moderately exposed coast, there is a barren area of varying width between the *Prasiola* belt and the ubiquitous dark-coloured lichens. An interesting correlation may be made between the degree of exposure and the width of each of the belts of vegetation. In all instances, as exposure increases, the bands become narrower and higher on the shore, and on the most exposed rock faces they do not form at all. The banding of the high littoral was the same on both east and west sides of the peninsula.

Also present, but to lesser extents, on the exposed coast are *Enteromorpha micrococca* and *Rhodochorton purpureum*. I have collected the former from a few small colonies in direct sunlight growing at the same

level as *Prasiola crispa*, high on a slightly protected shore where the amount of spray was almost negligible. These plants are tortuous, reduced in size, with short lateral proliferations and exceptionally thick cell walls. Their colour is lighter than the dark green of similar plants in a protected environment. At *Fishing Point*, immediately to the north of Hebron, *R. purpureum* was collected high on an extremely exposed coast, where it occurred in small patches as a dull red turf on the shaded sides of rocks. Here it was occasionally wetted by sea spray, but more often by surface runoff from the land. Lower on the shore, almost continually submerged even during low tides, a brighter coloured and more luxuriant turf of this species was attached to the undersides of rocks.

Below *Enteromorpha micrococca* but well above the mid-littoral, one finds early in the summer on the most protected surfaces of rocks such plants as *Ulothrix*, *Urospora*, and *Pylaiella*, the last-named being mostly dominant through the year. High in the littoral zone, in a few restricted areas in the vicinity of the mouths of the Koksoak and False rivers, in the southern part of Ungava Bay,¹ I have observed a fucoid closely resembling *F. distichus* subsp. *anceps*. These plants were attached to relatively smooth rock of an exposed coast well above the subsp. *evanescens* association, immediately below the orange-black zone and subject to long intervals of desiccation. Their appearance is somewhat intermediate between the high-growing emergent form of subsp. *distichus* and Powell's subsp. *anceps*, having slightly wider branch margins and being generally less robust than the latter. In all instances these intermediate plants are uniformly darker than the typical tide-pool plants with consistently fewer cryptostomata in their upper portions. These small scattered colonies of *Fucus*, stunted by exposure, are the only fuci on the rock of this kind of coast.

In September and October, 1955, all three of these high intertidal forms (subsp. *distichus*, subsp. *anceps* (?), and the emergent form of subsp. *distichus*) were observed with immature receptacles; maturation occurs during late winter or early spring.

I have distinguished two subspecies of *Fucus* in the upper littoral zone, *F. distichus* subsp. *distichus*, which includes both the tide-pool and emergent forms, and the plant that I have referred to as intermediate between subsp. *distichus* and subsp. *anceps*, which I am regarding as a form of subsp. *anceps*. The Stephensons describe their "*F. filiformis*" as "... locally common in high level tide pools, but apparently playing no general part in the zonation seen on open rock." They clearly refer to the plant that I have treated as subsp. *distichus*. Both these upper littoral subspecies are morphologically widely different from the typical *F. distichus* subsp. *evanescens* of moderately exposed coasts, which normally occurs at and just below the limits of low tide. Nevertheless, all the intermediate stages between the small linear tide-pool plants and the robust typical form can be seen at a single station, particularly one which includes a variety of secondary habitats ranging from an extremely exposed to a moderately

¹Plants were collected from similar populations in comparable "open" areas near "Thunder Hole," Mount Desert Island, Maine, September, 1952.

exposed environment. Jónsson states there can be no doubt of this relationship: "To any one who has seen this endless variation in nature, it seems so certain that it is due to the influence of outside factors, that experimental proof is almost superfluous."

The greater portion of the mid-shore remains barren of algae until midsummer when the rocks become sparsely covered with dense patches of *Ulothrix* and *Pylaiella*, these populations similar to but less extensive than those of moderately exposed coasts. The lower intertidal regions and the high sublittoral area may support a low dense turf vegetation restricted to submerged cracks in pools and rocks of the shore. The species listed below are almost consistently found in this habitat:

Chaetomorpha melagonium

Spongomorpha arcta

Pylaiella littoralis

Sphacelaria arctica

Dilsea integra

Ahnfeltia plicata

Phycodrys rubens

Polysiphonia arctica

Polysiphonia urceolata

Rhodomela confervoides

Of these plants, *Sphacelaria*, *Dilsea*, *Ahnfeltia*, and *Phycodrys* are the most abundant. In this turf it is not uncommon to find both *Phycodrys* and *Polysiphonia* much reduced in size, reproducing vegetatively by means of stolons and forming upright branches at frequent intervals. In this manner plants of these genera may extend considerable distances in cracks.

All the plants common to moderately exposed coasts are present in this major habitat but are mostly confined to the lower tide pools, small areas behind rocks and cracks in substantial rock. Where the shore largely consists of boulders and cobbles (Plate VII A and B) that are relatively unstable, being moved about by violent waves and ice, vegetation is almost absent. During June, July, and part of August, substrates of this nature remained barren in each area visited. At the height of the growing season only *Ulothrix flacca* and *Pylaiella littoralis* could be observed attached to these rocks.

Sublittoral Algae. Because of the ruggedness of much of the exposed coast and the violence typical of the surf here, coupled with the frequent lack of a boat from which to observe and collect offshore plants, my knowledge of the sublittoral communities is limited. Even cursory inspection, however, readily reveals two aspects of the vegetation of this part of the shore: 1. extensive coverage of the bottom by coralline algae (*Lithothamnion* sp.), 2. small beds of relatively low kelps. The associations of Laminariaceae here differ from those of moderately exposed coasts where both beds and plants are large. In relatively shallow water (8 to 16 metres) these communities consist of a small number of species:

Alaria grandifolia

Agarum cribrosum

Laminaria groenlandica

Laminaria nigripes

Laminaria solidungula (Plate VIII A and B)

Since I had relatively few opportunities to observe such communities, it is quite possible that other species of kelp not seen by me belong to this assemblage. In every instance the dominant algae are *Laminaria nigripes* and *Alaria grandifolia*. In this respect also, the kelp association here differs from that of moderately exposed coasts, where *L. longicruris* dominates.

The following species have been collected from exposed coasts. Those most prevalent are marked with an asterisk.

MYXOPHYCEAE

**Calothrix scopulorum*

CHLOROPHYCEAE

Gloeocystis scopulorum

Urococcus foslieanus

Codiolum pusillum

Ulothrix flacca

Enteromorpha micrococca

Monostroma fuscum

**Prasiola crispa*

Chaetomorpha melagonium

Spongomorpha arcta

Urospora penicilliformis

PHAEOPHYCEAE

**Pylaiella littoralis*

Chaetomorpha plumosa

Sphacelaria arctica

**Ralfsia fungiformis*

Lithoderma extensum

Elachistea fucicola

**Chordaria flagelliformis*

Desmarestia aculeata

Stictyosiphon tortilis

**Petalonia fascia*

Scytosiphon lomentaria

Agarum cribrum

Alaria grandifolia

**Laminaria groenlandica*

**Laminaria nigripes*

Laminaria solidungula

Fucus distichus subsp. *distichus*

Fucus distichus subsp. *anceps*

**Fucus distichus* subsp. *evanescens*

RHODOPHYCEAE

Rhodochorton purpureum

Dilsea integra

**Hildenbrandia prototypus*

**Lithothamnion* sp.

Euthora cristata

Rhodophyllis dichotoma

Ahnfeltia plicata

**Halosaccion ramentaceum*

**Rhodymenia palmata*

Antithamnion boreale

Ceramium sp.

Ptilota serrata

Membranoptera alata

Membranoptera denticulata

Phycodrys rubens

Odonthalia dentata

Polysiphonia arctica

Polysiphonia urceolata

Rhodomela confervoides

**Rhodomela lycopodioides*
f. *flagellaris*

Periodicity

The changes occurring in the algal vegetation of exposed coasts are slight compared with those which take place in other types of marine habitats of the North. As a direct consequence of severe conditions, except for a few high littoral species, the annual vegetation does not begin to develop until the middle of July, probably lasting through October in most areas. On the basis of my observations I am able to state few facts concerning periodicity, and what I can say, in most instances, is relative to the median portion of the growth cycle.

Populations of *Prasiola* were present by the time I arrived on the coast, and *Enteromorpha* and *Pylaiella* appeared in the upper littoral zone toward the last week of June. Large communities of *Ulothrix flacca* (Plate VII A and B) and *Pylaiella littoralis* colonized the low intertidal rocks beginning in late July. By the second week in August, portions of the lower intertidal rock supported patches of the *Chordaria* association. The growth of this community of brown algae, occurring so extensively on moderately exposed coasts, is much reduced on fully exposed shores.

In general, one can find here, all the annuals occurring in less exposed habitats; the populations, however, which are small and develop later in summer, are limited to the more sheltered niches. Their period of growth, therefore, is quite short, in some instances probably not longer than ten weeks.

TIDE POOLS

Tide pools are a normal feature of the intertidal rock along exposed rock-bound coasts and retain varying amounts of water while the tide is out. These depressions or crevices, ranging widely in size, depth, and

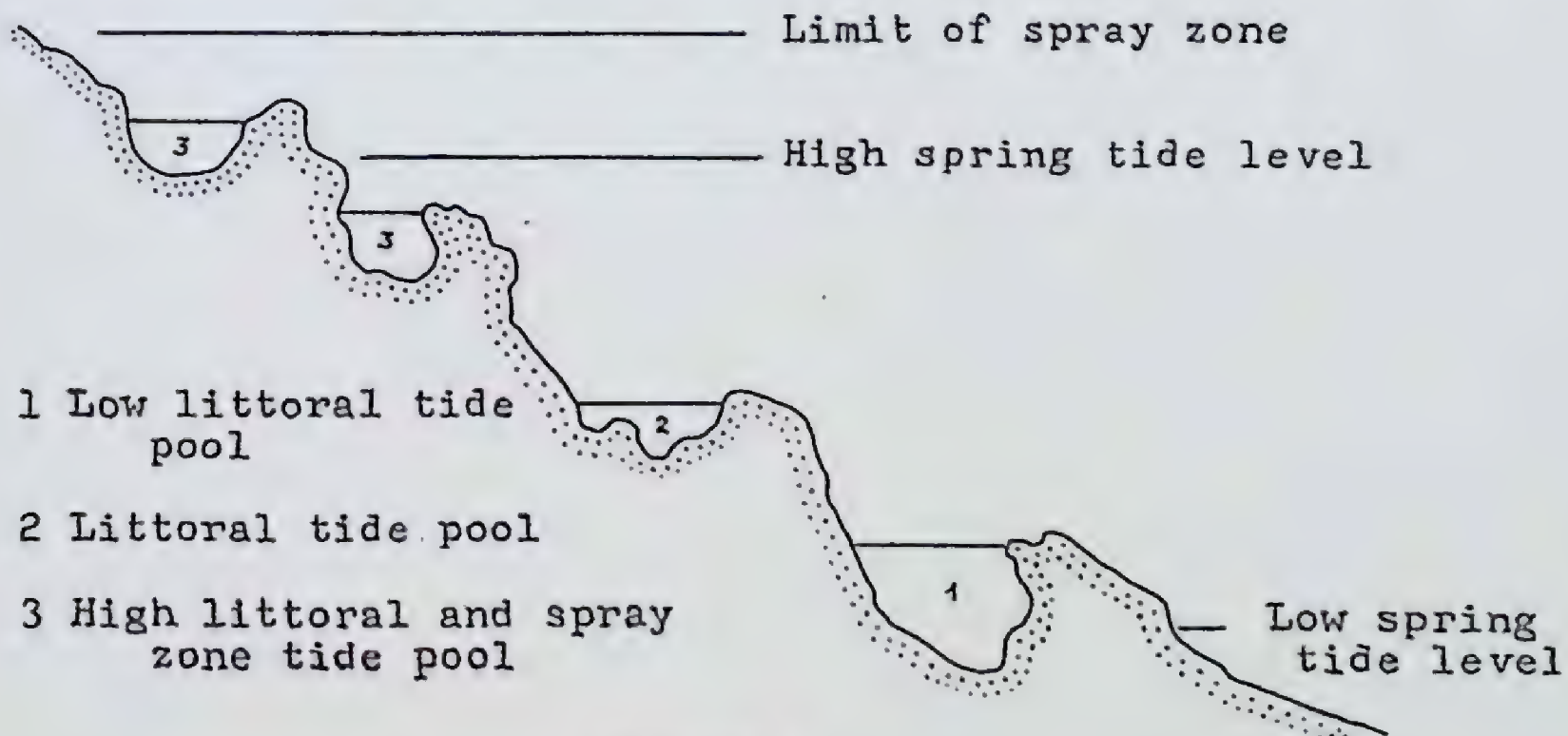


Figure 1

configuration, are common in the areas investigated and reach their highest frequency toward the northwest tip of the peninsula. Here tides are high, rock is uniformly present in the intertidal zone, and the coast is generally exposed. All these factors contribute to tide pool formation.

Following Cotton (1912), Johnson and Skutch (1928), Gislen (1930), and others, I have distinguished three types of tide pools on the basis of their vertical distribution in the intertidal zone, namely: (1) low littoral tide pools, (2) littoral tide pools, and (3) high littoral and spray zone tide pools (Figure 1). The height of the littoral zone and the distance between high and low littoral tide pools vary considerably with the different tidal amplitudes of the various regions of the Canadian Northeast. The following discussion of each type of pool, with its vegetation, is based upon qualitative observations and collections made throughout the general area.

Ecological Factors in Tide Pools

Adverse ecological conditions in the littoral zone of exposed northern stations generally restrict algal communities to tide pools. Plant associations are related to the type of pool in which they occur, as a direct result of the specific environmental conditions connected with that type. Pools may be characterized by the degree of their exposure and the temperature and salinity of the water they contain. Exposure is determined by the distance of the pool above the level of low tide and the intensity and duration of insolation; these are apparently the factors most significant in regulating the nature of the contained plant associations.

The elevation of the pool is of primary importance because it influences the amount of exposure both to surf and sunlight, which in part regulate the water temperature and salinity of the pool. Where the coast is moderately exposed with a gradually sloping shore, a classification of pools based on their elevation can well be adapted, and the plants in each pool correlated with the position of that pool. If, however, the shore is extremely exposed to surf and rises steeply from the sea, the turbulence of the water, the irregularities of the rock, and the relatively uniform water temperature and salinity all lessen the importance of the position of the pool as a determining factor affecting its vegetation. Consequently, as a result of severe wave action, some of the sublittoral species can be found in tide pools situated as much as $1\frac{1}{2}$ to 2 metres higher, relative to the level of spring tides, on exposed coasts than at less exposed stations. This condition is further accentuated when the smaller niches in tide pools are sheltered from direct light. Therefore, the criterion of pool elevation as a basis for classification should not be rigidly applied in some places.

Factors less important than elevation in their effect on pool vegetation are the general slope of the shore, the microtopography of the bottom and walls of the pool, the kind of bottom, and the volume of water contained. Although the pH of tide pools may be significant in some areas, especially in the uppermost pools, at present there are not sufficient data available for discussion. Ambler and Chapman (1950) and others determined quantitatively that pH changes are the result of the nature and extent of plant and

animal associations within each tide pool. Fluctuations are mostly small, from 7.6 to 8.9 (Johnson and Skutch, 1928). The pH becomes higher as plant populations increase and lower as animal populations increase (Klugh, 1924). I feel, however, that pH should not be considered a limiting factor, especially in view of the reduced size of both the plant and animal populations in tide pools of the north. The duration and intensity of insolation are also affected by the shape of the pools, those with steep or overhanging walls offering considerably more shade and protection from the movements of ice and water than do shallow pools with sloping walls.

Vegetation

Low Littoral Tide Pools. Pools of this type lie below the level of low spring tides. The lowest tide pools, partially protected from the most violent action of the surf and other water currents, primarily contain populations of perennials, but also some annuals that come and go during the ice-free period (Plate VI B). These pools differ from true sublittoral habitats only in that the force of the surf is somewhat decreased. Depending chiefly upon the degree of exposure to surf and sunlight, the plant associations of these pools show a wide range of morphological types. One striking example of this can be seen in the variation shown by *Laminaria nigripes*. In the lowermost tide pools where the turbulence is greatest, *L. nigripes* typically is reduced in length from the much longer sublittoral forms, but remains longer than broad, the blade narrowly and abundantly dissected with a cuneate or cuneate-cordate base, and the holdfast well developed at the base of a stipe less than one-quarter the length of the blade. Bell and MacFarlane (1933) report a similar condition for some plants of the low littoral in the vicinity of Halifax. The same species in quiet pools takes on an altogether different appearance; the blade is usually much longer, frequently as broad as long, little dissected with a few broad segments or remaining entire, in rare instances becoming cup-shaped, the base strongly cordate with the stipe reduced to a few centimetres in length. Other algae of quiet pools may also be well developed with strong tendencies to proliferate laterally; these plants, having holdfasts reduced in size although widely and delicately branched, are always less twisted and torn.

The walls of the basins low on the shore are densely colonized by various forms of *Fucus distichus* subsp. *evanescens*. Of the 'northern' forms of this subspecies, the most striking is a dwarfed plant of wave-swept coasts, which grows sporadically among the larger tide-pool plants of the same subspecies. Large plants are found in sheltered tide pools, whereas intermediate forms between the larger and dwarf plants of the 'northern' tide-pool form of subsp. *evanescens* are evident with modified exposure.

Another dwarf ecological form of the northern plants of subsp. *evanescens* was also found low on the shore, growing exposed rather than in the pools, where the coast is little sheltered. This plant closely resembles the alga called by Rosenvinge (1893) *F. inflatus* f. *membranaceus* and named by Jónsson (1912) *F. inflatus* f. *exposita*¹.

¹ *F. inflatus* f. *exposita* = *F. distichus* L. subsp. *anceps* (Harv. et Ward ex Carruthers) Powell, n. comb.

It differs from the tide-pool form in being generally smaller, flabellate rather than bushy, and in having fronds narrower with shorter receptacles which remain compressed at maturity. At the most northerly latitudes, where the two dwarf forms of the low littoral attain their greatest expression, it is noteworthy that representative plants of subsp. *edentatus* were nowhere evident.

Below the fuci toward the bottom of low littoral pools usually is a dense population of small kelp, under two metres, more commonly less than one metre, and notably well developed in response to the turbulence of its environment. The following species of the Laminariaceae are most generally present, the more common species marked by an asterisk.

Agarum cribrosum

**Alaria grandifolia*

*Laminaria groenlandica*¹

**Laminaria saccharina*

Laminaria solidungula

**Laminaria nigripes*

The three most common species, *L. nigripes*, *L. saccharina*, and *A. grandifolia*, constitute what I have called the 'nigripes' association. At times *L. saccharina* may be absent from this community, seemingly having a preference to deeper water habitats of moderately exposed coasts. In such instances *L. groenlandica* is invariably found in place of the former.

At the bases of these kelps is a low turf association which may appear in deep rock crevices as well. The relatively constant constituents of this turf are *Sphacelaria arctica*, *Rhodomela lycopodioides* f. *flagellaris*, *Phycodrys rubens*, *Ahnfeltia plicata*, *Polysiphonia arctica*, *P. urceolata*, and *Antithamnion boreale*, and small plants of *Dilsea integra*. With less shelter, *Antithamnion* is usually attached to other plants rather than directly to the floor and sides of the pool. Many of these turf plants are commonly attached to the extensive patches of *Hildenbrandia* and *Lithothamnion* seen on the most shaded rock surfaces.

The bottoms of the deeper basins are scattered with numerous tightly compacted, highly branched, luxuriant plants of *Euthorea cristata*, *Rhodophyllis dichotoma* (Plate XI B), *Ptilota serrata*, *Membranoptera alata*, *M. denticulata*, *Rhodomela confervoides*, *Odonthalia dentata*, and infrequently, *Ptilota plumosa*, in addition to the plants previously mentioned. Here also, handsome tufts of *Stictyosiphon tortilis* and *Chaetopteris plumosa* were observed, both apparently rarely gregarious. Where there is much turbulence, *Lithoderma extensum* forms a characteristic dark-brown rough coating over many of the rocks on the bottom of these pools, similar to that formed by *Ralfsia fungiformis* in higher pools.

Two members of the Chlorophyceae found here are *Monostroma fuscum* and *Chaetomorpha melagonium*, both of which may be attached in large numbers to rock or to the kelp holdfasts. During midsummer, following spore discharge, *Chaetomorpha* becomes heavily epiphytized by such plants as *Pylaiella littoralis*, *Elachistea fucicola*, *Dictyosiphon foeniculaceus*, and *Rhodochorton penicilliforme* and less commonly with *Sorapian kjellmanni*.

¹It is quite possible that I have confused the identity of *L. saccharina* with that of *L. groenlandica* when making field determinations. As the macroscopic differences are few and exceedingly subtle, it is almost impossible to distinguish the two species in the field. Statements relative to their distribution are based upon my field notes substantiated by laboratory studies.

Typical of these low pools are plant associations that one normally finds in the true sublittoral. Examples of the more common species of these associations are listed below:

<i>Monostroma fuscum</i>	<i>Laminaria saccharina</i>
<i>Chaetomorpha melagonium</i>	<i>Laminaria solidungula</i>
<i>Spongomorpha arcta</i>	<i>Hildenbrandia prototypus</i>
<i>Chaetopteris plumosa</i>	<i>Euthora cristata</i>
<i>Lithoderma extensum</i>	<i>Rhodophyllis dichotoma</i>
<i>Agarum cribrosum</i>	<i>Halosaccion ramentaceum</i>
<i>Alaria grandifolia</i>	<i>Rhodymenia palmata</i>
<i>Laminaria groenlandica</i>	<i>Rhodomela lycopodioides</i> f. <i>flagellaris</i>
<i>Laminaria nigripes</i>	

Littoral Tide Pools. Pools in which the water is above the level of low tide belong to this category. Scattered throughout the greater part of the intertidal zone, they are most often characterized by dense and often bulky populations of fuci; *Ralfsia fungiformis* (Plate IX A) and such crustose forms as *Lithothamnion* sp. and to a lesser extent *Ralfsia verrucosa* cover the rock surface beneath the masses of fuci. Species of *Ralfsia* and the coralline *Lithothamnion* are noticeably in competition in the lower pools. With the increased insolation and reduced salinity so common in the upper pools, *Ralfsia* becomes the dominant form, covering large irregular areas of the sides and bottoms of the tide pools. If the overhanging vegetation is dense and the pool is relatively deep, *Hildenbrandia prototypus*, *Lithothamnion* sp. and, at times in the lowermost pools, *Lithoderma extensum* and some of the more delicate members of the Rhodophyceae are found at the bases of the fuci. Of the Rhodophyceae, such species as *Antithamnion boreale*, *Euthora cristata*, and *Membranoptera denticulata* are most commonly epiphytes, but *Rhodomela confervoides*, *Ahnfeltia plicata*, and others can be found attached to the rocks in crevices or to the sides of the pools beneath the fuci. Rarely, however, does the growth of these small phaeophyceans equal the development of these species found in the lowermost pools of the littoral. Of more frequent occurrence here are dense growths of phaeophycean annuals, which in late summer and early autumn completely dominate these habitats, with the possible exception of the fuci, growing profusely in every depression that retains even the slightest amount of water. Ubiquitous species as *Pylaiella littoralis*, *Elachistea fucicola*, *Chordaria flagelliformis*, and *Scytosiphon lomentaria* appear to have a rather limited distribution, seen less frequently and at widely scattered stations. More massive plants are restricted to the various forms of *Fucus distichus*, and in the highest littoral pools *Fucus vesiculosus* is also represented by a multiplicity of forms. Littoral pools with the highest elevation and therefore with the longest periods of emergence and illumination contain primarily members of the Chlorophyceae in place of the Rhodophyceae of the lowermost pools, the most common species being *Spongomorpha arcta*, *Monostroma fuscum*, *Cladophora glaucescens*, and at times *Ulva lactuca* var. *rigida*.

High Littoral and Spray Zone Tide Pools. The uppermost positions of the shore frequently wetted by storm waves and spray may contain tide pools. Here rapid changes in water temperature, fluctuating salinities, even to the point of the pool water being stratified with a layer of fresh water at the surface, and severe exposure to insolation, accompanied by frequent changes from rock to sand substrate may influence the development of diverse and peculiar forms of well-known species. Algae of this kind form typical associations for these habitats and are unlike plants of the lower tide pools previously described.

In many of the higher pools, especially along their shaded upper edges, I have seen a zonation of *Calothrix* and *Urococcus*, which is similar to that found in the upper levels of protected shallows and moderately exposed coasts, differing only in that its width is much reduced, each of its bands usually being less than 15 centimetres wide. As in the more exposed habitats, *Calothrix* superimposes on *Urococcus*, with which it forms a distinct orange-black belt. Associated with these algae may be a variety of other greens and blue greens, but these species occupy a relatively unimportant position in this association.

Most distinctive in many of these high pools during much of the growing season are dense carpet-like populations of *Pylaiella littoralis* covering the walls and bottom, particularly where it is sandy. In other sandy-bottomed pools, *Enteromorpha intestinalis*, *Monostroma fuscum*, *Spongomorpha arcta*, or *Cladophora glaucescens* may be the dominant species rather than *Pylaiella*. With them one sees forms of *F. distichus* subsp. *distichus*, *Chordaria flagelliformis*, and other members of the Phaeophyceae that are found growing only under these extreme conditions. In late summer the bushy *F. distichus* subsp. *distichus* supports a considerable number of epiphytes, of which *Pylaiella*, *Monostroma*, and *Enteromorpha* are the most prevalent. *Pylaiella* and a much reduced form of *Dictyosiphon foeniculaceus* are found in large numbers as epiphytes of the dominant annual, *Chordaria flagelliformis*. As it does on the lower shore, *Ralfsia fungiformis* (Plate IX A) forms large irregular patches covering much of the rock that is partially sheltered from direct sunlight.

The reduction of the number of species from the sublittoral pools to the upper littoral and spray zone tide pools agrees with the conclusions of Skinner (1903) in his attempts to analyse the tide-pool flora of Port Renfrew, B. C., and the observations of Cotton (1912) at Clare Island.

The following list includes the most common species found in the three types of tide pools in the area investigated. The most prevalent species are designated with an asterisk.

MYXOPHYCEAE

**Calothrix scopulorum*

CHLOROPHYCEAE

Gloeocystis scopulorum
Urococcus foslieanus
Codiolum pusillum
Ulothrix flacca
Capsosiphon fulvescens
Enteromorpha erecta
**Enteromorpha intestinalis*

**Monostroma fuscum*
Prasiola crispa
Chaetomorpha melagonium
Cladophora glaucescens
**Spongomorpha arcta*
Spongomorpha lanosa

PHAEOPHYCEAE

**Pylaiella littoralis*
Chaetopteris plumosa
Sphacelaria arctica
Ralfsia fungiformis
**Ralfsia verrucosa*
Lithoderma extensum
Elachistea fucicola
**Chordaria flagelliformis*
Stictyosiphon tortilis
Petalonia fascia
Scytosiphon lomentaria

Dictyosiphon foeniculaceus
Agarum cribrorum
**Alaria grandifolia*
Chorda filum
Laminaria groenlandica
**Laminaria nigripes*
**Laminaria saccharina*
Laminaria solidungula
Saccorhiza dermatodea
**Fucus distichus subsp. distichus*
**Fucus distichus subsp. evanescens*

RHODOPHYCEAE

Rhodochorton penicilliforme
Rhodochorton purpureum
Dilsea integra
Polyides caprinus
**Hildenbrandia prototypus*
Lithothamnion sp.
Euthora cristata
Rhodophyllis dichotoma
**Ahnfeltia plicata*
**Halosaccion ramentaceum*
Rhodymenia palmata
Antithamnion boreale

Ceramium sp.
Ptilota plumosa
Ptilota serrata
Membranoptera alata
Membranoptera denticulata
Phycodrys rubens
Polysiphonia arctica
Polysiphonia urceolata
Odonthalia dentata
**Rhodomela confervoides*
Rhodomela lycopodioides f.
flagellaris

Periodicity

PORT BURWELL

The vicinity of Port Burwell was visited for five days in late August, 1954, and from July 12 through August 28 in 1955. At this station it was possible for me to see the succession of tide-pool annuals from shortly after they first appeared until most of the species had matured.

From the time the ice breaks up until late in June, tide pools at Port Burwell remain barren of annuals. During this time the upper

pools are drab, usually characterized by dense populations of the dominant *F. distichus* subsp. *distichus*. Later in the summer these plants support large populations of the most common epiphytes of *Fucus*, *Pylaiella*, and *Elachistea*. During this season, lower pools are equally colourless and are populated largely by *F. distichus* subsp. *evanescens* and rich colonies of small plants of *Laminaria nigripes* and *Alaria grandifolia*.

The first seasonal changes in these tide pools occur much earlier in the spring than changes elsewhere in the littoral zone. It is possible to correlate the time that growth begins with the degree of exposure to which the tide pools are subjected, the relatively quiet areas seemingly more conducive to early algal growth than the more exposed stations. Development of tide-pool annuals at Port Burwell had begun by the middle of June in 1955, which would seem to be rather late in the year. At that time, however, sea ice was still packed closely against the shore and remained so throughout most of July and for short intervals during the first part of August.

The first annuals observed here were *Ulothrix flacca*, *Monostroma fuscum*, very small plants of *Spongomorpha arcta* and *Pylaiella littoralis*, and *Halosaccion ramentaceum*. These species, either beginning their development under the ice or soon after the first signs of the break-up, were seen in large numbers in the most sheltered pools. Of these, *Pylaiella* and *Spongomorpha* remain through the summer and into the autumn; *Halosaccion*, in most areas, reaches its maximum growth toward the middle of August and then gradually becomes less conspicuous; *Ulothrix* is even more short lived, being an early summer annual in the North and rapidly losing prominence by late July. Although an occasional mature individual may be found throughout the summer months, *Monostroma* has striking peaks of growth during which the delicate thalli may be found in great numbers in all tide pools of the upper half of the shore. The cyclic growth of these plants appears to be closely correlated to tidal periodicity, the growth peaks being related to the highest spring tides. Species of *Enteromorpha*, not found during the first half of July, appeared in the uppermost pools and developed rapidly toward the last of the month, seemingly reaching maturity by mid-August. Many of these plants showed no signs of senescence in late August, and I presume they survive at least through October, probably being removed from the rocks soon after by the heavy seas of autumn. In general, most of the tide pool Chlorophyceae appear toward the first of July and reach their greatest development during the last week of August. Early in September they dominate the vegetation of the upper littoral pools, while at the same time the lower pools begin to assume a drab brown appearance from the *Chordaria*, *Petalonia*, and *Seytosiphon* populations, forming at that time a distinct contrast with the green of the pools of the upper shore.

The final stages in the development and senescence of these plants were not observed. However, from my observations at Port Burwell during July and August and studies elsewhere through September and October, I conclude that the peak of growth for summer annuals in tide pools

extends probably through the month of October. Tide-pool annuals remain healthy somewhat longer than annuals of the littoral zone because of the partial protection afforded them by their environment.

Of the time and method of their removal from the rock substrate, little can be said that is based upon my own observations. It is supposed that the typically severe autumn surf and the abrasive movements of the first-formed ice quickly strip most of these plants from the rocks.

The following list of species, although including only the larger, more conspicuous algae, represents annuals whose presence greatly changes the aspect of the algal pool communities:

CHLOROPHYCEAE

<i>Ulothrix flacca</i>	<i>Monostroma fuscum</i>
<i>Enteromorpha compressa</i>	<i>Prasiola crispa</i>
<i>Enteromorpha erecta</i>	<i>Cladophora glaucescens</i>
<i>Enteromorpha intestinalis</i>	<i>Spongomorpha arcta</i>
<i>Enteromorpha micrococca</i>	

PHAEOPHYCEAE

<i>Pylaiella littoralis</i>	<i>Petalonia fascia</i>
<i>Elachistea fucicola</i>	<i>Scytosiphon lomentaria</i>
<i>Chordaria flagelliformis</i>	<i>Dictyosiphon foeniculaceus</i>

RHODOPHYCEAE

<i>Dilsea integra</i>	<i>Halosaccion ramentaceum</i>
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HEBRON

The tide-pool communities in the vicinity of Hebron, although differing slightly in their algal components from those at Port Burwell, appear to have a seasonal periodicity comparable to that of more northern stations. My conclusions are based upon observations made during two growing seasons. I was able to see the early spring and late autumn stages of most of the algae in the Hebron tide pools, except for a few species of unknown life span.

During June and early July the tide pools of inner Hebron Fjord are typically barren of annuals, the upper pools containing little but a few stunted perennials, while large populations of fuci dominate the lower pools. Annuals in the high pools begin their development with the appearance of *Pylaiella* and a slightly proliferated form of *Enteromorpha intestinalis*. During the first week of July when I first saw these pools, *Pylaiella* was the dominant annual, remaining so in many pools throughout the entire season. Occasional patches of *Ulothrix* and *Monostroma* were also seen, but they were rare when compared with the frequency of *Pylaiella*, uncommon itself at that time.

Toward the end of July, young plants of *Chordaria*, *Scytosiphon*, and *Petalonia* appeared everywhere in pools below the mid-littoral zone, forming dense populations by late autumn. Occasional colonies of *Elachistea fucicola* and *Rhodomela confervoides* develop about the same time as the dominant *Chordaria*.

Tide pools along moderately exposed and open coasts near Hebron present a flora markedly different in number of species from similar habitats of the inner fjord. Quite like the middle fjord pools during early spring, they lack even traces of an annual vegetation. As in the pools of the inner fjord, *Ulothrix*, *Monostroma*, and *Pylaiella* make their appearance first, followed shortly by the upper littoral tide-pool forms of *Enteromorpha intestinalis*, the dominant annual of the larger pools during late summer and autumn. A tufted form of *Pylaiella* and *Enteromorpha compressa* are often closely associated with *E. intestinalis* on the floor of the basins.

The lower depressions of exposed regions frequently contain dense tide-pool populations of short much-branched *Halosaccion ramentaceum* usually found immediately beneath a band of *Spongomorpha arcta*. These two species must appear soon after the ice begins to leave (approximately mid-June in some areas) as I have seen them in splendid but restricted colonies in many basins near Hebron during the first two weeks of July. The bright red of *Halosaccion* and the intense green of *Spongomorpha* add touches of colour to the otherwise dull littoral zone. As do other mid-littoral pools, those on the exposed coasts near Hebron become heavily populated by *Chordaria*, *Petalonia*, and *Scytosiphon* soon after the first week in July. Plants of these communities at Hebron were at their height during the last week of October after an exceptionally mild autumn. At that time I observed attached algae in dense, luxuriant populations, which, except for fuci, I had not seen before in the littoral zone of any coast in the North.

Rhodomela will be considered here as an annual, although late in June and early in July I have frequently collected the well-worn thalli of the preceding year's plants, only the main axes and a few branch stubs remaining. As summer comes, these plants begin to proliferate, and by late autumn they have formed sizable plants for the second year. The same phenomenon occurs in the genus *Chordaria*, especially among the plants in the higher, more protected tide pools. I consider this "biennial" type of life cycle the exception rather than the rule, for apparently only few individuals remain through the winter to regenerate new growth the following summer.

In the lowermost tide pools during the first part of July, 1954, I observed *Dilsea integra* (Plate IX B) in large numbers. These plants were found only in the most shaded niches, sheltered from direct sunlight by overhanging rock or by the dense growth of *F. distichus* subsp. *evanescens*. By this time the upper portion of the blades of many plants had begun to deteriorate, the plants in the most advanced stages of

decomposition growing highest. As *Dilsea* gradually disappeared from the high sublittoral and lowermost tide pools, it was only by intense searching that I was able to find the few small colonies persisting to the first weeks of August. Later that month, large plants of *Dilsea* were dredged in quiet bays and off moderately exposed coasts; as these plants were also beginning to show signs of age, I conclude that *Dilsea* completes its life span in one season. When the same station was again visited in September and October, 1955, I was unable to find even a vestige of this species in the littoral or upper sublittoral zone. Almost every plant collected during the last part of July, 1954, was in a late stage of its reproductive cycle. I believe that germination of carpospores (presumably released by the breakdown of the tissues of the parent plant) occurs in late autumn or early spring, followed by rapid growth during the spring and early summer.

FORT CHIMO

Tide pools of the southernmost region of Ungava Bay (near the mouth of the Koksoak River) were visited in June, 1955, and for short periods during September 1954 and 1955.

The vegetation in the pools at Fort Chimo, Quebec (approximately 30 miles from the coast of Ungava Bay) on June 21, 1955, consisted of small tufts of *Cladophora glaucescens* attached to the rock at the bottom of shallow pools and a thick coating of *Calothrix scopulorum* and other associated blue-green algae forming a felt over the rocks in the upper part of the pools. In September, in addition to these plants, *Enteromorpha intestinalis* and the *Vaucheria* turf were conspicuous.

Midway to the coast from Fort Chimo, tide pools in the upper part of the shore contained on June 25 and 26 the following annual species: *Cladophora glaucescens*, *Spongomorpha arcta*, *Enteromorpha intestinalis*, and *Pylaiella littoralis*. Closer to the Ungava coast were additional plants, such as *Monostroma fuscum* and the battered remains of *Chordaria* and *Rhodomela*. Here, *Monostroma* was the prominent member of the lower littoral pools at this time, forming dense light-green tufts on the sides and bottoms of the pools.

SPECIES TABULATION

The following tabulation of species deals mainly with those which are significant components of the marine flora of Labrador and northwestern Newfoundland. Since only a few of the inconspicuous species have been included, this list should not be considered complete. There are, in addition, numerous forms that are not sufficiently represented in the collections to be mentioned and many others that require considerably more study before their identity can be established. There is also a group of undescribed species which in time will be included in a more complete tabulation of the algae of these areas.

Numerous first records for Labrador and Newfoundland are also included in this list. One asterisk designates species collected for the first time in these areas; two asterisks designate species previously unknown from arctic and subarctic regions of the Canadian northeast.

MYXOPHYCEAE

CHAMAESIPHONACEAE

- ***Entophysalis conferta** Drouet and Daily
Hebron Fjord, Saglek Fjord, Koksoak River.

RIVULARIACEAE

- Calothrix scopulorum** Drouet and Daily
Common throughout the entire region.

SCYTONEMATACEAE

- Scytonema** sp.
Fort Chimo.

OSCILLATORIACEAE

- Lyngbya** sp.
Hebron Harbour, McLelan Strait.

CHLOROPHYCEAE

PALMELLACEAE

- ****Gloeocystis scopulorum** Hansgirg
Hebron Harbour, Port Burwell, Nanook Pool, McLelan Strait, False River Bay.
****Urococcus foslieanus** Hansgirg
Hebron Harbour, Port Burwell, Nanook Pool, McLelan Strait, False River Bay.

CHLOROCOCCACEAE

- ****Codiolum pusillum** (Lyngbye) Kjellman
Hebron Harbour, False River Bay.

ENDOSPHERACEAE

- ****Chlorochytrium schmitzii** Rosenvinge
Hebron Harbour, McLelan Strait, False River Bay.
****Chlorochytrium dermatocolax** Reinke
Hebron Harbour, Port Burwell.

ULOTRICHACEAE

- Ulothrix flacca** (Dillwyn) Thuret
Newfoundland, southern Labrador, and common throughout more northerly collection stations.

- **Entocladia flustrae** (Reinke) Batters
Infrequently seen north of Nain.

CHAETOPHORACEAE

- **Pringsheimella scutata** (Reinke) Schmidt et Petrak
General throughout the area.

GOMONTIACEAE

- *Gomontia polyrhiza** (Lagerheim) Bornet et Flahault
Port Burwell.

ULVACEAE

- **Capsosiphon fulvenscens** (C. Agardh) Setchell et Gardner
Okak Bay, Hebron Harbour.

- *Enteromorpha compressa** (Linnaeus) Greville
Hebron Harbour, Saglek Fjord, Port Burwell.

- **Enteromorpha erecta** (Lyngbye) J. Agardh
Port Burwell.

Enteromorpha intestinalis (Linnaeus) Link

Frenchmans Head, Port à Choix, Okak Bay, Hebron Fjord, Hebron Harbour, Port Burwell, Munro Harbour, McLelan Strait, False River Bay.

- *Enteromorpha marginata** J. Agardh
False River Bay.

***Enteromorpha micrococca** Kützing

Newfoundland, southern Labrador, and common throughout more northerly collection stations.

- *Enteromorpha minima** Nägeli
Frenchmans Head, Okak Bay.

- **Enteromorpha plumosa** Kützing
False River Bay.

Monostroma fuscum (Postels et Ruprecht) Wittrock f. **blyttii**
(Areschoug) Collins

Nutak Bay, Hebron Harbour, Eastern Harbour, Port Burwell, Fox Harbour, Nanook Pool, McLelan Strait, False River Bay, Koksoak River.

Monostroma grevillei (Thuret) Wittrock
Port Saunders.**Monostroma oxyspermum** (Kützing) Doty
Port-à-Choix.**Monostroma pulchrum** Farlow
Frenchmans Head.

Monostroma leptoderma Kjellman

Port Burwell, Port Harvey.

****Percursaria percursa** (C. Agardh) J. Agardh

False River Bay.

Ulva lactuca Linnaeus v. **rigida** (C. Agardh) Le Jolis

Port Burwell, Port Harvey.

PRASIOLOACEAE

Prasiola crispa (Lightfoot) Meneghini

Throughout the entire region, less common to the south.

CLADOPHORACEAE

****Chaetomorpha linum** (Müller) Kützinger

Amity Bay, Hebron Harbour, Eastern Harbour.

Chaetomorpha melagonium (Weber et Mohr) Kützinger

Okak Bay, Amity Bay, Hebron Harbour, Eastern Harbour, Nachvak Fjord, Port Burwell, Munro Harbour, Fox Harbour, Nanook Pool, False River Bay.

Cladophora glaucescens (Griffiths et Harvey) Harvey

Port Burwell, Koksoak River, Fort Chimo.

****Cladophora rudolphiana** (C. Agardh) Harvey

Port Burwell, Koksoak River.

Cladophora rupestris (Linnaeus) Kützinger

Brigg Bay.

Rhizoclonium riparium (Roth) Harvey

Napartok Bay, Hebron Fjord, Hebron Harbour, Watchman Island, Eastern Harbour, Saglek Fjord, Port Burwell, Mission Cove, Koksoak River.

Spongomorpha areta (Dillwyn) Kützinger

Hebron Harbour, Saglek Fjord, Port Burwell, Munro Harbour, Fox Harbour, Nanook Pool, throughout entire region.

***Spongomorpha lanosa** (Roth) Kützinger

Hebron Harbour, Eastern Harbour, Port Burwell.

***Urospora penicilliformis** (Roth) Areschoug

Koksoak River.

XANTHOPHYCEAE

VAUCHERIAEAE

****Vaucheria compacta** (Collins) Collins

False River Bay, Koksoak River, Fort Chimo.

****Vaucheria sphaerospora** Nordstedt
False River Bay, Koksoak River, Fort Chimo.

****Vaucheria submarina** Berk *sensu* De Wildeman
False River Bay, Koksoak River, Fort Chimo.

PHAEOPHYCEAE

ECTOCARPACEAE

Pylaiella littoralis (Linnaeus) Kjellman
Common at all stations throughout the region.

***Ectocarpus confervoides** (Roth) Le Jolis
Cooks Brook to Frenchmans Head, Okak Bay, Hebron Harbour, Saglek Fjord, False River Bay.

****Ectocarpus dasycarpus** Kuekuck
Port Burwell.

****Ectocarpus fasciculatus** (Griffiths) Harvey
Port Burwell.

***Ectocarpus siliculosus** (Dillwyn) Lyngbye
Port Burwell, False River Bay, Koksoak River.

Ectocarpus tomentosoides Farlow
Infrequent, general distribution.

****Giffordia ovata** (Kjellman) Kylin
Port Burwell.

****Streblonema oligosporum** Strömfelt
Hebron Fjord, Hebron Harbour.

****Streblonema fasciculatum** Thuret
Hebron Harbour, Saglek Bay entrance.

Streblonema accidioides (Rosenv.) Foslie
Port Burwell, Munro Harbour.

****Streblonema stilophore** Crouan
Port Burwell.

SPHACELARIACEAE

***Chaetopteris plumosa** (Lyngbye) Kützing
Kai-Kai Inlet, Hebron Fjord, Hebron Harbour, Eastern Harbour, Kangelaksiorkvik Fjord, Port Burwell, Munro Harbour, Fox Harbour, Nanook Pool.

***Halopteris scoparia** (Linnaeus) Savageau
Northern Newfoundland (north of Brigg Bay).

***Sphacelaria radicans** (Dillwyn) C. Agardh
Hebron Harbour.

Sphacelaria arctica Greville

Common throughout the entire region.

RALFSIACEAE

****Ralfsia clavata** (Carmichael) Crouan *sensu* Farlow
Port Burwell.

***Ralfsia fungiformis** (Gunner) Setchell et Gardner
Collected at all stations north of Nain.

Ralfsia verrucosa (Areschoug) J. Agardh
Hebron Fjord, Hebron Harbour, Port Burwell, Nanook Pool.

LITHODERMATACEAE

***Lithoderma extensum** (Crouan) Hamel
Hebron Fjord, Port Burwell, Munro Harbour, Fox Harbour.

***Sorapion kjellmanni** (Wille) Rosenvinge
Hebron Harbour, Port Burwell, mouth of False River Bay.

ELACHISTACEAE

***Elachistea fucicola** (Velle) Areschoug
Common throughout the entire region.

CHORDARIACEAE

****Leptonema fasciculatum** Reinke
Common at most sheltered stations.

****Eudesme virescens** (Carmichael) J. Agardh
Hebron Harbour, Saglek Fjord, False River Bay, Koksoak River.

Sphaerotrichia divaricata (C. Agardh) Kylin
Hebron Harbour, Nachvak Fjord.

Chordaria flagelliformis (Müller) C. Agardh
Common throughout the entire region.

DESMARESTIACEAE

Desmarestia aculeata (Linnaeus) Lamouroux
Common throughout the entire region.

Desmarestia viridis (Müller) Lamouroux
Amity Harbour, False River Bay, Koksoak River.

STRIARIACEAE

****Isthmoplea sphaerospora** (Carmichael) Kjellman
Saglek Fjord, Port Burwell, False River Bay, Koksoak River.

****Stictyosiphon tortilis** (Ruprecht) Reinke

Frenchmans Head, Red Bay, Amity Harbour, Hebron Fjord, Hebron Harbour, Saglek Bay entrance, Eastern Harbour, Nachvak Fjord, Port Burwell, Munro Harbour, Fox Harbour, False River Bay, Koksoak River.

PUNCTARIACEAE

****Delamarea attenuata** (Kjellman) Rosenvinge

Hebron Harbour, Saglek Fjord.

***Litosiphon filiformis** (Reinke) Batters

Port Burwell, Port Harvey, McLelan Strait.

****Litosiphon pusillus** (Carm.) Harvey

Hebron Harbour.

***Petalonia fascia** (O. F. Müller) Kuntze

Frenchmans Head, Port-à-Choix, Hebron Fjord, Hebron Harbour, Saglek Fjord, Eastern Harbour, Nachvak Fjord, Port Burwell, False River Bay, Koksoak River.

****Punctaria latifolia** Greville

Hebron Fjord.

****Punctaria plantaginea** (Roth) Greville

Nachvak Fjord.

****Scytosiphon lomentaria** (Lyngbye) C. Agardh

Hebron Harbour, Eastern Harbour, Saglek Fjord, Port Burwell, Port Harvey, False River Bay, Koksoak River.

DICTYOSIPHONACEAE

****Coilodesme bulligera** Strömfelt

Port Harvey.

Dictyosiphon foeniculaceus (Hudson) Greville

Nain, Kai-Kai Inlet, Hebron Fjord, Hebron Harbour, Eastern Harbour, Saglek Fjord, Nachvak Fjord, Kangalaksiorvik Fjord, Port Burwell, False River Bay, Koksoak River.

LAMINARIACEAE

Agarum cribrum (Mertens) Bory

Common throughout the entire region.

***Alaria grandifolia** J. Agardh

Common throughout the entire region.

***Chorda filum** (Linnaeus) Lamouroux

Nutak Bay, Hebron Fjord, Hebron Harbour, Saglek Fjord, Nachvak Fjord.

***Chorda tomentosa** Lyngbye

Frenchmans Head, Hebron Harbour, Saglek Fjord, False River Bay, Koksoak River.

***Laminaria cuneifolia** J. Agardh

False River Bay, Koksoak River.

***Laminaria groenlandica** Rosenvinge

Hebron Fjord, Hebron Harbour, Port Burwell, Fox Harbour, Nanook Pool, Port Harvey.

Laminaria longieruris De la Pylaie

Common throughout the entire region.

***Laminaria nigripes** J. Agardh

Red Bay, Hebron Fjord, Hebron Harbour, Watchman Island, Saglek Fjord, Port Burwell, Munro Harbour, Fox Harbour, Nanook Pool, Port Harvey, McLelan Strait, east coast of Ungava Bay, False River Bay, Koksoak River.

Laminaria saccharina (Linnaeus) Lamouroux

Red Bay, Amity Harbour, Hebron Fjord, Hebron Harbour, Port Burwell, Nanook Pool, False River Bay, Koksoak River.

***Laminaria solidungula** J. Agardh

Okak Bay, Nutak Bay, Napartok Bay, Hebron Fjord, Hebron Harbour, Watchman Island, Eastern Harbour, Port Burwell, Fox Harbour, Nanook Pool, McLelan Strait, False River Bay, Koksoak River, Fort Chimo.

Laminaria sp.

Throughout southeastern Ungava Bay.

Laminaria sp.

Hebron Harbour, drift from deep water.

***Saccorhiza dermatodea** (De la Pylaie) J. Agardh

Red Bay, Okak Bay, Nutak Bay, Hebron Fjord, Hebron Harbour, Cape Morhardt, Saglek Fjord, Port Burwell, Fox Harbour, Munro Harbour, Nanook Pool, Port Harvey.

FUCACEAE

Ascophyllum nodosum (Linnaeus) Le Jolis

Brigg Bay, Okak Bay, Kai-Kai Inlet, Hebron Fjord, Port Burwell, Nanook Pool, east coast of Ungava Bay, False River.

***Fucus distichus** Linnaeus subsp. **distichus**

Common throughout the entire region.

***Fucus distichus** L. subsp. **anceps** (Harv. et Ward ex Carruthers) Powell, n.comb.

Near mouths of Koksoak and False rivers.

***Fucus distichus** L. subsp. **edentatus** (De la Pylaie) Powell, n. comb.
Red Bay, Saglek Bay.

Fucus distichus L. subsp. **evanescens** (C. Agardh) Powell, n. comb.
Common throughout the entire region.

Fucus vesiculosus Linnaeus
Common throughout the entire region.

RHODOPHYCEAE

BANGIACEAE

Bangia fuscopurpurea (Dillwyn) Lyngbye
Frenchmans Head.

****Porphyra miniata** (Lyngbye) C. Agardh
Saglek Fjord, Kangalaksiorkvik Fjord, McLelan Strait, Koksoak River.

ACROCHAETIACEAE

***Rhodochorton penicilliforme** (Kjellman) Rosenvinge
Port Burwell.

***Rhodochorton purpureum** (Lightfoot) Rosenvinge
Hebron Fjord, Hebron Harbour, Watchman Island, Cape Morhardt, Saglek Fjord, Eastern Harbour, Port Burwell, Nanook Pool, McLelan Strait, False River Bay, Koksoak River.

DUMONTIACEAE

Dilsea integra (Kjellman) Rosenvinge
Nutak Bay, Amity Bay, Napartok Bay, Hebron Fjord, Hebron Harbour, Eastern Harbour, Port Burwell, Munro Harbour, Koksoak River.

***Dumontia incrassata** (O. F. Müller) Lamouroux
Frenchmans Head.

RHIZOPHYLLIDACEAE

****Polyides caprinus** (Gunnerus) Papenfuss
Hebron Harbour.

SQUAMARIACEAE

Hildenbrandia prototypus Nardo
Common throughout the entire region.

****Peyssonnelia rosenvingii** Schmitz
Southern Labrador and northwestern Newfoundland.

CORALLINACEAE

****Lithothamnium lenormandi** (Areschoug) Foslie
Southern Labrador and northwestern Newfoundland.

Lithothamnium laeve (Strömfelt) Foslie
Northwestern Newfoundland.

Lithothamnium glaciale Kjellman

Common throughout the entire region.

Lithothamnium sp.

Southern Labrador and northwestern Newfoundland.

Corallina officinalis Linnaeus

Southern Labrador and northwestern Newfoundland.

KALLYMENIACEAE

Euthora cristata (Linnaeus ex Turner) J. Agardh

Red Bay, Amity Bay, Hebron Harbour, Saglek Fjord, Eastern Harbour, Port Burwell, Nanook Pool, Port Harvey.

***Kallymenia schmitzii** De Toni

Amity Bay, False River Bay, Koksoak River.

CHOREOCOLACACEAE

***Ceratocolax hartzii** Rosenvinge

Hebron Harbour, False River Bay, Koksoak River.

****Harveyella mirabilis** (Reinsch) Schmitz et Reinke

Port Burwell, False River Bay, Koksoak River.

RHODOPHYLLIDACEAE

***Rhodophyllis dichotoma** (Lepeschkin) Gobi

Hebron Harbour, Saglek Fjord, Eastern Harbour, Port Burwell, Munro Harbour, Port Harvey, False River Bay.

PHYLLOPHORACEAE

Ahnfeltia plicata (Hudson) Fries

Cooks Brook to Frenchmans Head, Brigg Bay, Hebron Fjord, Hebron Harbour, Kangalaksiorkvik Fjord, Port Burwell, Munro Harbour.

***Phyllophora brodiaei** (Turner) J. Agardh

Nutak Bay, Eastern Harbour, False River Bay.

Phyllophora interrupta (Greville) J. Agardh

Nutak Bay, Amity Bay, Hebron Fjord, Hebron Harbour, Eastern Harbour, False River Bay, Koksoak River.

***Phyllophora membranifolia** (Goodenough et Woodward) J. Agardh

Southern Labrador and northwestern Newfoundland.

GIGARTINACEAE

Chondrus crispus Stackhouse

Northern Newfoundland.

RHODYMENIACEAE

Halosaccion ramentaceum (Linnaeus) J. Agardh

Common throughout the entire region.

Rhodymenia palmata (Linnaeus) Greville

Common throughout the entire region.

CERAMIACEAE

***Antithamnion boreale** (Gobi) Kjellman

Seen commonly at all stations north of Hebron.

Ceramium rubrum (Hudson) C. Agardh

Infrequent throughout the entire region.

Ceramium sp.

Hopedale, Amity Bay, Kai-Kai Inlet, Hebron Harbour, Saglek Fjord, Eastern Harbour.

****Ptilota plumosa** (Hudson) C. Agardh

Port Burwell, Munro Harbour.

Ptilota serrata Kützing

Common throughout the entire region.

Trailliella intricata (J. Agardh) Batters

Frenchmans Head.

Membranoptera alata (Hudson) Stackhouse

Hebron Fjord, Hebron Harbour, Eastern Harbour, Port Burwell, Munro Harbour, Nanook Pool, Port Harvey, False River Bay, Koksoak River.

Membranoptera denticulata (Montagne) J. Agardh

False River Bay, Koksoak River.

***Pantoneura baerii** (Postels et Ruprecht) Kylin

False River Bay, Koksoak River.

Phycodrys rubens (Hudson) Batters

Red Bay, Nutak Bay, Amity Bay, Hebron Fjord, Hebron Harbour, Port Burwell, Munro Harbour, Nanook Pool, False River Bay, Koksoak River.

RHODOMELACEAE

Odonthalia dentata (Linnaeus) Lyngbye

Nutak Bay, Hebron Harbour, Port Burwell, Munro Harbour, Fox Harbour, Nanook Pool, False River Bay, Koksoak River.

***Polysiphonia arctica** J. Agardh

Amity Bay, Hebron Fjord, Hebron Harbour, Port Burwell, Munro Harbour, Nanook Pool, False River Bay, Koksoak River.

***Polysiphonia urceolata** (Lightfoot) Greville

Port-à-Choix, Hebron Harbour, Eastern Harbour, Port Burwell, Nanook Pool, False River Bay.

Rhodomela confervoides (Hudson) Silva

Common throughout the entire region.

****Rhodomela lycopodioides** (Linnaeus) C. Agardh f. **flagellaris** Kjellman

Kai-Kai Inlet, Hebron Harbour, Port Burwell, Munro Harbour, Nanook Pool, False River Bay, Koksoak River.

SUMMARY

1. Collections and studies of the marine algae of Labrador and Newfoundland were made through two ice-free seasons, a total of eight months, during which late spring, summer, and autumn floras were observed. Five major habitats, viz., mud flats, protected shallows, moderately exposed coasts, exposed coasts, and tide pools are described, and the ecological factors operating in each are discussed. Algal species are listed, and data are given concerning periodicity of the algae in each habitat.

2. Mud flats are characterized by a paucity of species, but each is represented by a large number of individuals, collectively forming a low, often continuous turf. The dominant plants are species of *Vaucheria*. Other littoral habitats associated with mud flats show a few more species than are found on the flats.

3. Protected shallows of bays and fjords are characterized by large populations of *Fucus vesiculosus*. Few additional species are present, of which the Rhodophyceae are the least important.

4. Moderately exposed coasts contain the richest populations of algae in arctic-subarctic regions. During much of the year the algae found between tide-marks are restricted to tide pools and sheltered crevices. Annuals appearing by mid-summer may densely clothe the rocks of the middle and lower parts of the littoral zone. These are dominated by the Chordaria association consisting of *Chordaria flagelliformis*, *Petalonia fascia*, and *Scytosiphon lomentaria*.

5. Fully exposed coasts, typically subjected to severe environmental forces, support meagre populations of algae. Deep-water communities are the largest, and plants in the littoral zone are almost restricted to late-appearing annuals. The Chordaria association is dominant here also.

6. Tide pools may be grouped into three kinds on the basis of the position of the pool on the shore. Upper littoral and spray zone tide pools are characterized by populations of chlorophycean annuals and *F. distichus* subsp. *distichus*; mid-littoral pools by dense growths of small brown annuals, *Fucus vesiculosus* and *F. distichus* subsp. *evanescens*; and low littoral tide pools by communities of small kelp and a variety of small leafy and fleshy rhodophycean algae.

7. The salient factors limiting the growth and development of marine algae in arctic-subarctic environments are the presence of moving ice-masses, the reduction of salinities because of melting sea ice and seasonal land runoff, the configuration of the coast, and the nature of the substrate.

8. The vegetation for the entire area is concentrated in the sublittoral regions and contains relatively few species but large numbers of individuals, some of which may reach an immense size. The appearance of the flora is monotonous and mostly lacks colours.

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PLATE I

A. Map of Newfoundland and Labrador

B. Map of Ungava Bay

Numbers 1 to 37 denote collection stations. (See Plate II for those in the vicinity of Killinek Island.)

PLATE I

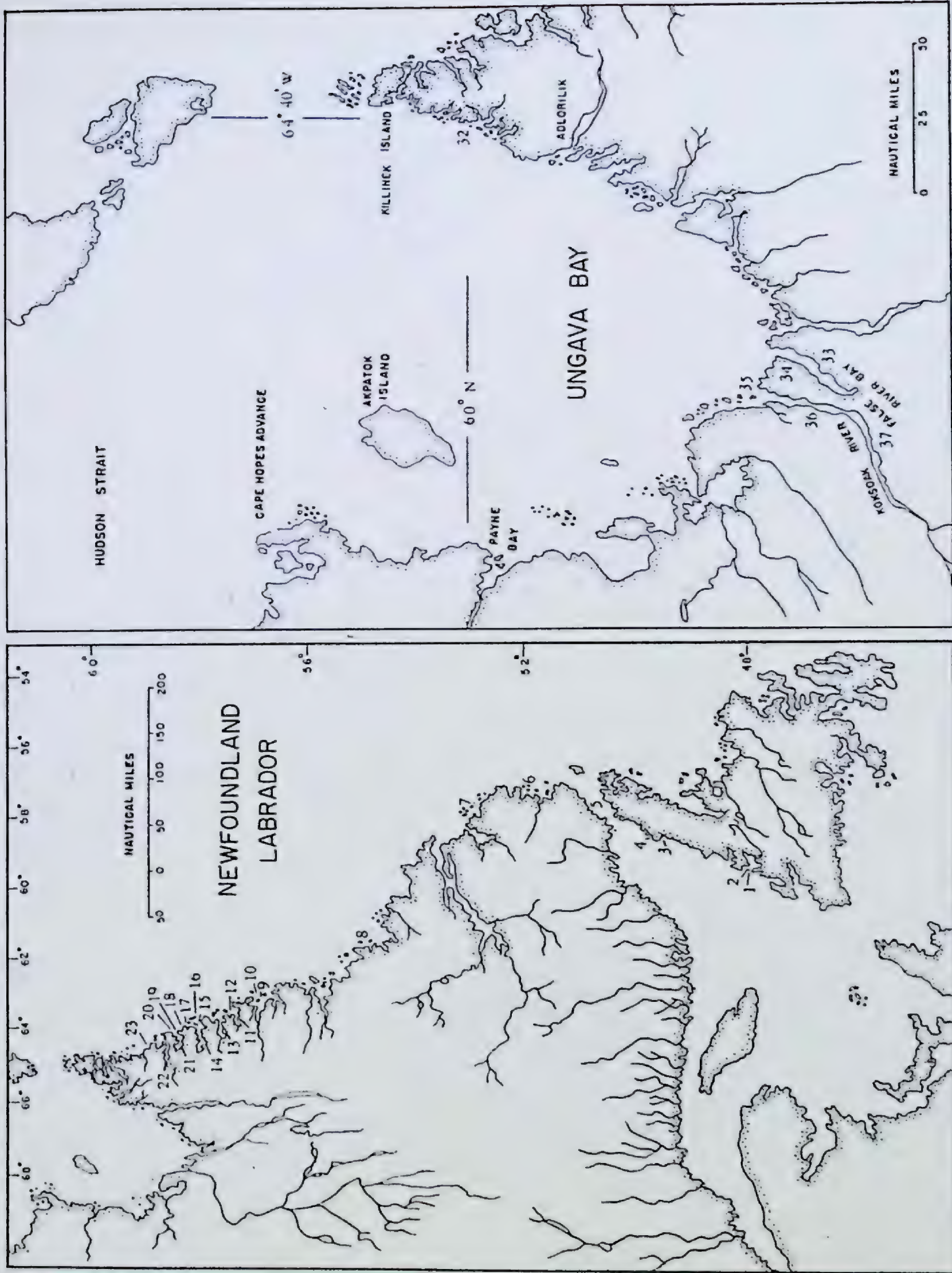


PLATE II

A. Map of Forbes Sound.

B. Map of northwestern Killinek Island.

The asterisk in Burwell Harbour designates the approximate location of my base camp, 1955.
(Numbers 24 to 31 denote collection stations.)

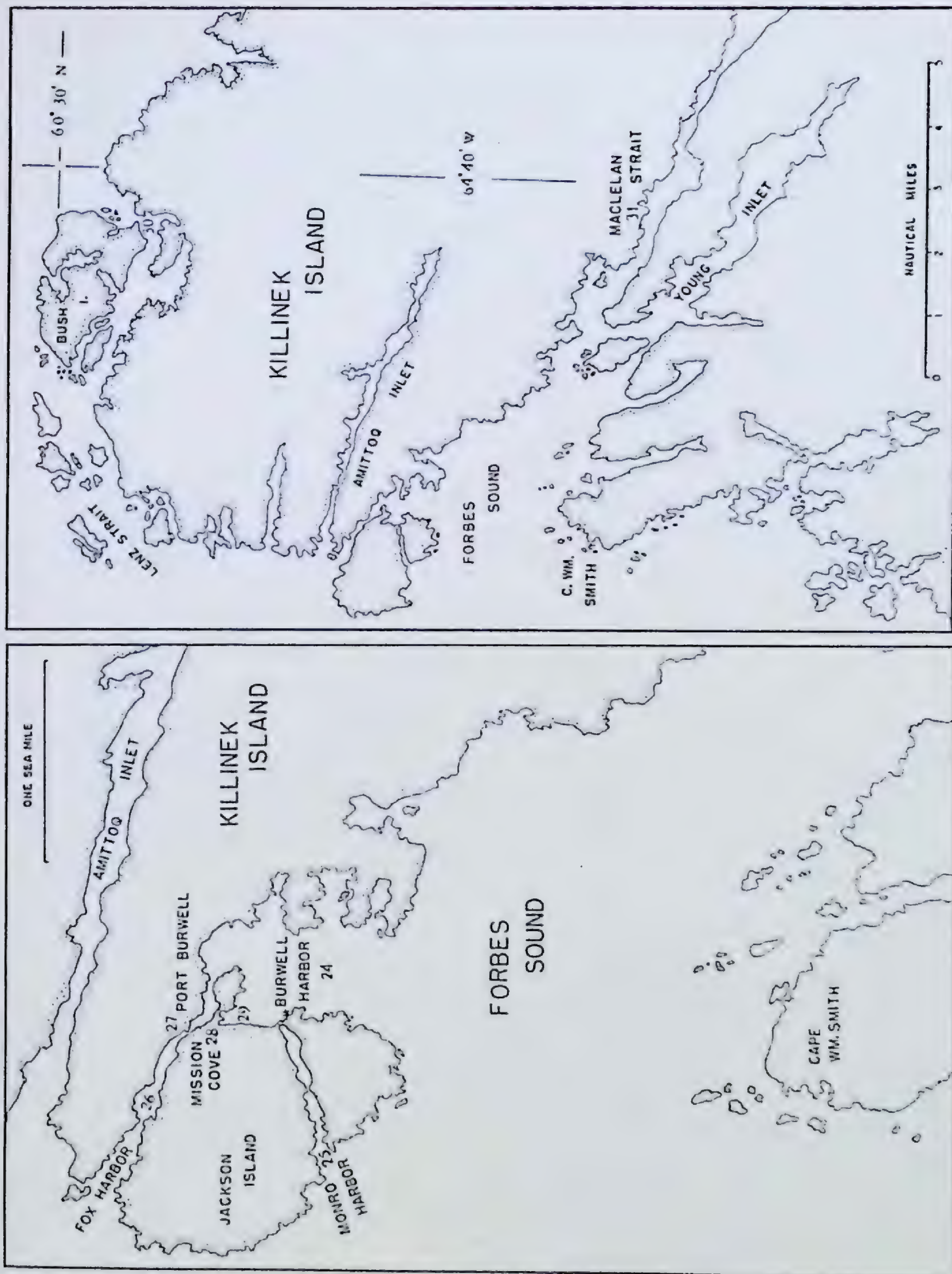


PLATE III

A. Pack-ice crowding the shore.

A portion of the shore near Port Burwell, typical of July and early August, 1955.

B. Ice-scoured rocks of the littoral zone.

Intertidal rocks near Hebron worn smooth by the abrasive movements of ice and surf.



PLATE IV

A. Remains of ice-foot at Port Burwell.

The shelf of ice that persists in the upper littoral zone in bays and fjords after the ice-sheet has broken apart and moved out.

B. Ice-floes stranded on skerries.

Midway to the head of Hebron Fjord, approximately at low tide, ice-worn skerries appear barren of algae on their upper surfaces but with dense growths of fuci along their lower edges.



PLATE V

A. Sheltered head of Nachvak Fjord.

The shore consists of loose unconsolidated small forms of rock unsuitable for the attachment of most algal species.

B. Intertidal mud flats, Fort Chimo.

The regions between tide-marks at Fort Chimo consist of mud flats dominated by *Vaucheria*, with scattered cobbles and boulders which support a few myxophycean and chlorophycean species.



PLATE VI

A. Fully exposed coast.

A portion of the coast near Saglek; algal growth here is much restricted owing to the seasonal ice and almost constant surf.

B. Low littoral tide pool.

The algal growth of low littoral tide pools is typically luxuriant; zonation here includes *Spongomorpha arcta* at the upper right, *Halosaccion ramentaceum* immediately below forming a conspicuous band, and a dense community of kelp attached to the bottom.

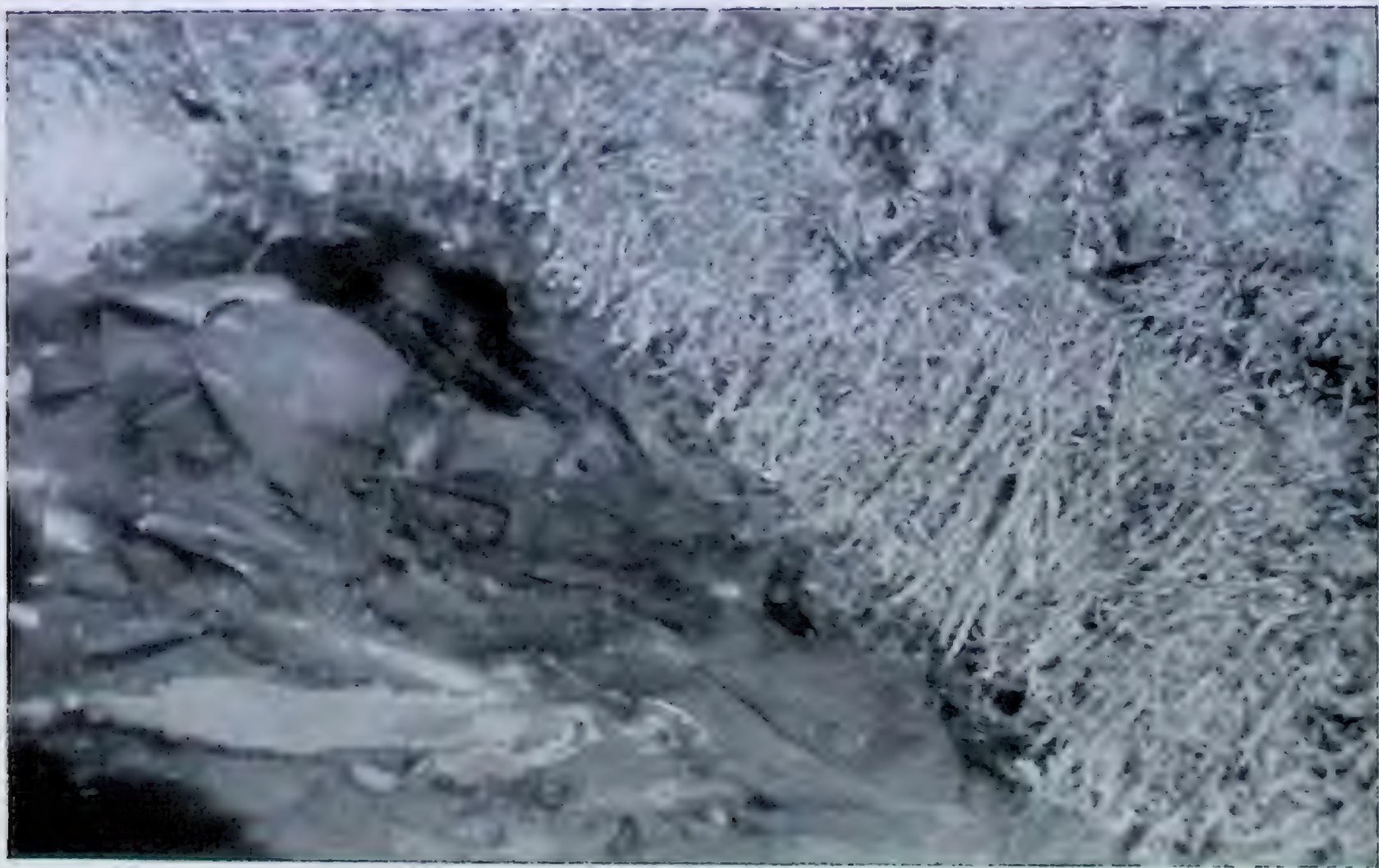


PLATE VII

A. Intertidal cobbles of an exposed shore.

Cobbles of metamorphic rock occurring low in the littoral zone, barren of algae for much of the year because of the instability of the substrate and extreme exposure of the habitat.

B. Intertidal cobbles of an exposed shore.

A similar substrate seen somewhat later in the summer season. Filamentous green and brown algae have colonized many of the rock faces. The alga seen here is chiefly *Ulothrix flacca*.



PLATE VIII

A. *Laminaria solidungula*, habit.

Small tide-pool forms of this species, which, in deep-water environments, may attain lengths exceeding 8 metres. Note the characteristically elliptic-reniform sori, discharged in the plant on the left, intact in the plant on the right.

B. *Laminaria solidungula*, holdfast.

The disc-like holdfast of this plant readily distinguishes it from all other members of this genus found in the Canadian Northeast.



PLATE IX

A. *Ralfsia fungiformis*, habit.

Especially common in northern regions of the Canadian Eastern Arctic and Subarctic, in tide pools and the upper sublittoral, covering rather considerable areas of rock surface.

B. *Dilsea integra*, habit.

A particularly large (17 centimetres), deep-water form dredged from water 14 metres deep; Napartok Bay.



PLATE X

A. Dredge haul on the deck of the "Blue Dolphin."

Plants of *Kallymenia schmitzii* (foreground) and *Agarum cribrosum* (background) dredged from a community dominated by these species.

B. *Kallymenia schmitzii*.

A particularly ruffled form of this species from the collection shown in the above figure.

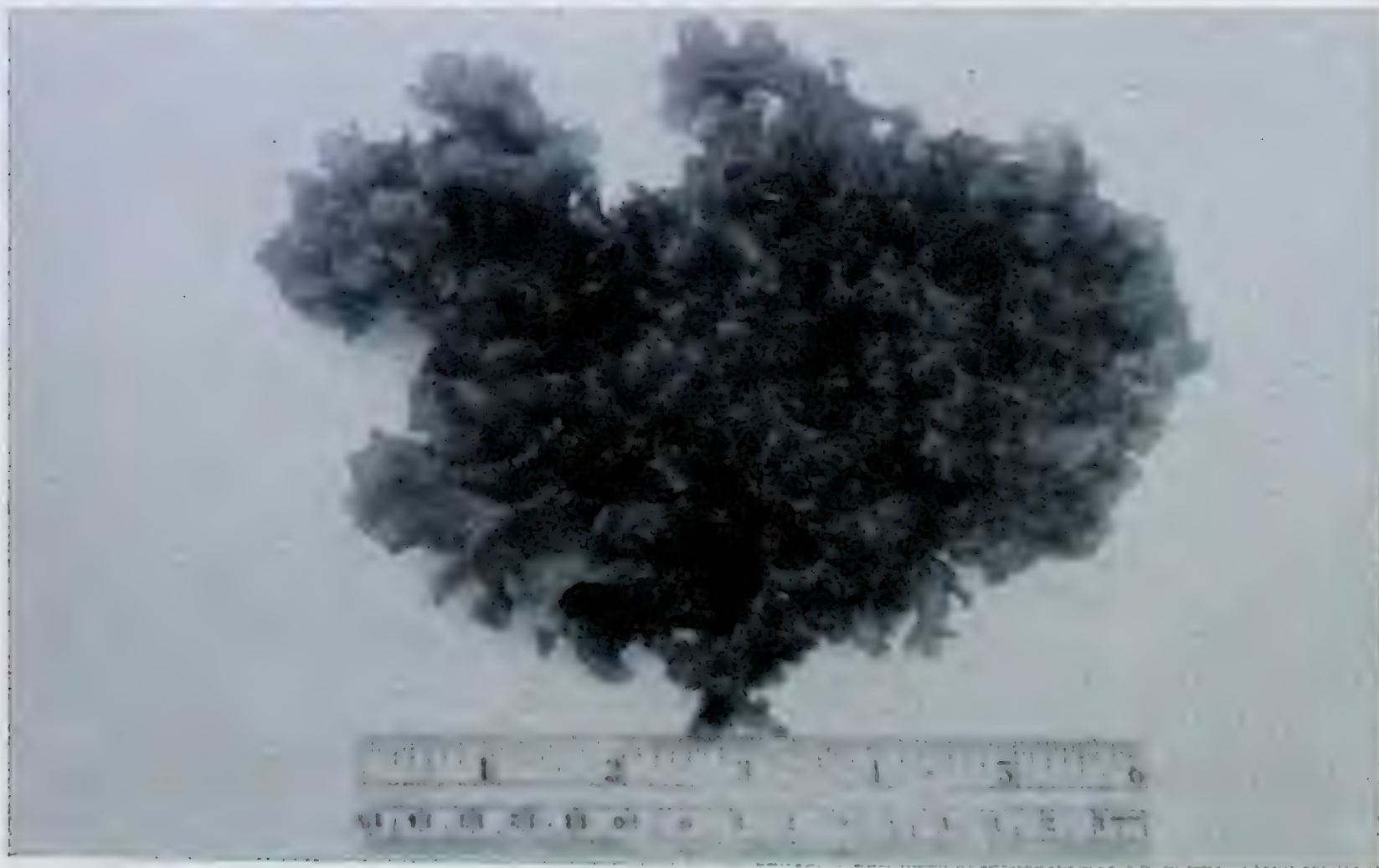


PLATE XI

A. *Rhodophyllis dichotoma*.

A broad form of this species typical of deep water.

B. *Rhodophyllis dichotoma* f. *setacea*.

The narrow form of this species, most common of the northern forms, especially in tide pools and in the upper sublittoral.



